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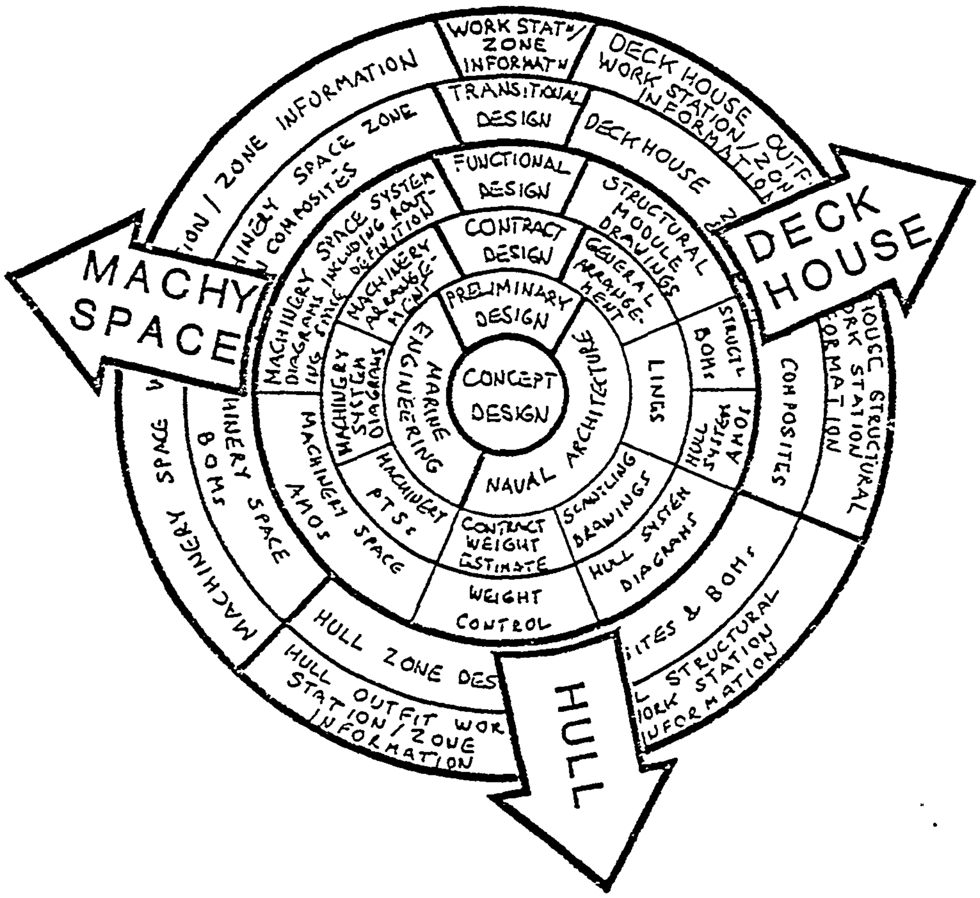
ENGINEERING MANAGEMENT

FOR

ZONE CONSTRUCTION OF SHIPS



BY

Thomas Lamb, B.Sc., P.E.
Director of Engineering

Tacoma Boatbuilding Company
Tacoma, Washington

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ENGINEERING MANAGEMENT FOR ZONE CONSTRUCTION OF SHIPS

by

Thomas Lamb B.Sc., P.E.

ABSTRACT

Zone construction has been proposed as the way for the U.S. shipbuilding industry to improve its productivity and survive the current hard times. Obviously as the production requirements for zone construction are different to traditional ship construction so are the engineering. While production could perform zone construction from traditionally prepared engineering it would do so inefficiently and after waiting a long time for most of the engineering to be completed before they could start, thus defeating one of the goals of zone construction.

The production department in a shipyard changing to zone construction will probably reorganize into major zone sections. To obtain maximum benefits from zone construction it is necessary for the engineering department to be like organized and managed. The paper therefore discusses engineering aspects that are influenced by the change to zone construction.

CONTENTS

1.0 INTRODUCTION

Management has been defined as the universal process of accomplishing work through others. It consists of handling and making decisions on many conflicating requirements at the same time. Because of this, management analysts try to eliminate the complexity by conveniently dividing it up into functions and then discuss each function and the relationships between them. The four functions that are always listed are:

- Planning
- Organizing -
- Directing
- Controlling

Other functions that are sometimes listed are:

o Leadership	(a directing function)
o Assembling Resources	(part of organizing)
o Staffing	(part of organizing)
o Training	(part of organizing)
o Communication	(part of directing)
o Decision Making	(involved in all functions)
o Budgeting	(a planning function)

The additional functions can all be considered subsets of the first four as shown by the relationships indicated in parentheses.

Planning is the WHO, WHAT, WHERE and WHEN decision phase of management. It utilizes tools such as Work Breakdown Structures, Task Listings, Sequencing, Networking and Critical Path Method along with engineering and manufacturing skills to select an efficient approach to designing, procuring material, and constructing a product.

Organizing consists of the design of the organization, its staffing and training.

Directing is the ordering by commands, instructing by example or suggesting by consultation, of the necessary actions to obtain the desired results. It is here that the "art of management" is truly most applied. This art, as well as controlling people, is the melding of the planning and organizing which in turn are tools or systems to determine if the "art" was successful in accomplishing the plan.

Controlling is the analysis of operating results in comparison with the plan If the results do not conform,. action must be taken to improve the future results so that the final outcome will achieve or better the plan. Controlling also involves feedback of the results so they can be used by planning in the future. The control of any business endeavor requires the following basic knowledge:

- o What has to be done?
- o When should it be done?
- o What resources does it require?

With this knowledge, managers can control the work if the following feedback is provided:

- o Is the work being done on schedule?
- o Is the performance better or worse than budgeted?
- o How can problems be corrected?

Any management control system must address all the above questions.

There is an obvious logical sequence of these functions for every project, namely, planning, organizing, directing and controlling. Once initiated, the control function may require continuous re-planning and re-directing if results are not to plan.

Some of these management aspects will be discussed in regard to Engineering for Zone Construction, but before this is done, it is worthwhile to set the scene to which they would be applied.

There have been and, notwithstanding the current world shipbuilding recession, still are many successful shipbuilding companies in the world. The engineering organization of these successful companies, although similar,

probably has significant differences. These differences are due to the development of the companies, their products, and the skills and experience of their employees and their managers. The development of today's shipbuilding engineering organizations evolved as engineering work was split into hull and machinery, and then into structure, outfit, hull systems and machinery, machinery and electrical. Through time, design and technical calculations were separated from working drawing preparation. In most engineering organizations, these divisions or as they are often called, disciplines, still exist. However, the way ships are designed and built has significantly changed over the last 25 years. It is surprising to many that engineering organization did not change during this time to suit the design and building methods.

In addition, during the same time frame, another significant change that directly affected engineering requirements occurred, namely; the demise of the craft apprenticeship system. This resulted in the workers being less 'skilled and experienced, and required more and easier to understand data and instructions from the engineering organizations. The craft organized shipyards worked from the minimum of engineering and-the well trained and experienced workers developed their own details. Because of this, engineering and production often were isolated from each other. Today's Zone Construction shipbuilding

necessitates a very close relationship between planning, engineering, and production employees. It also requires an intimate knowledge by the engineers of the methods used, and the difficulties involved in constructing a ship in the facility for which they work. Details can no longer be left to be solved by the loft, shipfitter, or pipe shop! Even though this approach appears to place more responsibility on the engineer, in general, it is more logical and interesting. Therefore, it is usually enthusiastically accepted by the engineer. Unfortunately, it has been met with mixed emotions by other departments in shipyards.

The reasons for this are many, ranging from incursion into "their area", to insulting their intelligence by the issue of simpler but better instructions. Neither reason, or any in between, are justifiable. Everyone in the shipyard should be working as a team, ready to adapt to whatever approach helps it to achieve the goal of competitive ships in minimum construction time. An efficient, successfully operated company should be like a set of precision gears, each department like many input shafts with gears meshing with the production department, which of course is the output shaft. 'This concept is shown in Figure 1. Incidentally, communication is the necessary lubricant for the organization (gear) and the collection of the lubricating oil and its processing for return to the

gear is the organization's feedback. For optimum performance, all service departments (input gears) must mesh with the production department (output gear) in exact accordance with the organization (gear) design. It must operate like a properly lubricated and maintained set of precision gears. If any service department tries to do more or less than it is required to, or if the production department tries to drive a service department, then the total organization output diminishes, and the output gear will become overloaded and may self destruct. Only by each part of the organization functioning as they are designed to, will the efficiency approach its optimum. A set of precision gears will achieve 98% efficiency. It is doubtful if any organization can claim any where near this value. Just as it is essential for the desing of a gear the detail requirements for each part of the organization must be fully understood to complete the design successfully. Therefore, it is essential that the objectives and results for each department be clearly defined, and the responsibility, authority and accountability be correspondingly assigned to the departments.

Like most things in life, there is more than one way to approach the design of an organization, but in all cases, the engineering goals must be clear and the resulting organization must be capable of achieving the goals.

Even then it is only possible if all involved use the organization in the way it is designed. If employees or worse, management, do not enthusiastically adopt the new organization, full benefit from the reorganization will not be achieved.

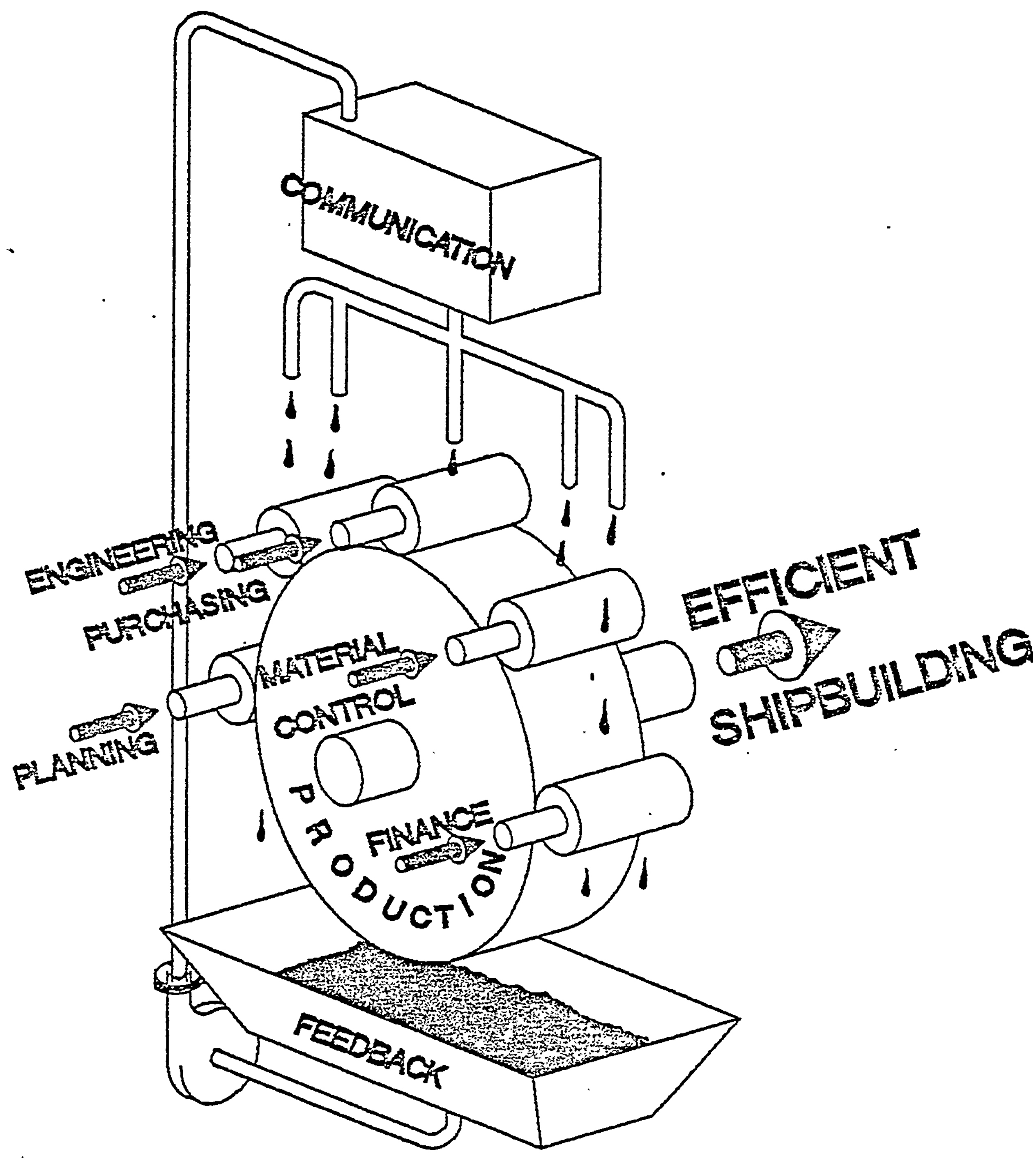


FIGURE 1 - THE COMPANY GEAR

2.0 WHAT IS ZONE CONSTRUCTION?

Zone Construction is the name given to the shipbuilding technique wherein the construction of the structure, distributive systems, outfit and equipment, and installation of same are integrated and occur when the ship is in modular or partially erected stage. The normal breakdown into system disciplines, such as structure (shell, deck, bulkhead, etc.), piping, HVAC, electrical, paint, etc., tend to disappear and all items become interim products. To accomplish this, the ship is divided into zones, thus the basis for the name. The division can be a hierarchical system or simply sequential, or any combination in between these extremes. Figure 2 is an example of the first type and Figure 3 the latter. A beneficial way to handle zone construction is to consider each ship zone as a work station and then the concept of zones can be integrated with the shipyard facility work stations.

Shipyards utilizing the Zone Construction approach are identifiable by constructing ship structure in modules (Figure 4) and incorporating extensive advanced outfitting (Figure 5) They will also be organized by major zone (or product) such as Hull, Deckhouse, and Machinery Spaces. Fully outfitted deckhouses will be the form rather than the exception (Figure 6). In addition, a major aspect is the compression of the design/build cycles shown in Figure 7.

The benefits of Zone Construction are many and are covered in the many MarAd/SNAME SP-2 publications (1, 2 & 3) and the MarAd/Avondale Technology Transfer Symposia (4). The major ones are as fellows:

- Improved productivity
- improved quality
- Improved worker safety
- Logical sequencing of work
- Earlier start to outfit fabrication and installation, thus better utilization of outfit trades throughout the duration of construction rather than heavy concentration near the end.
- Clearer responsibility for complete design and construction of each zone.

These all result from an integrated design and installation of outfit at or near ground level, in better facilities and at best attitude.

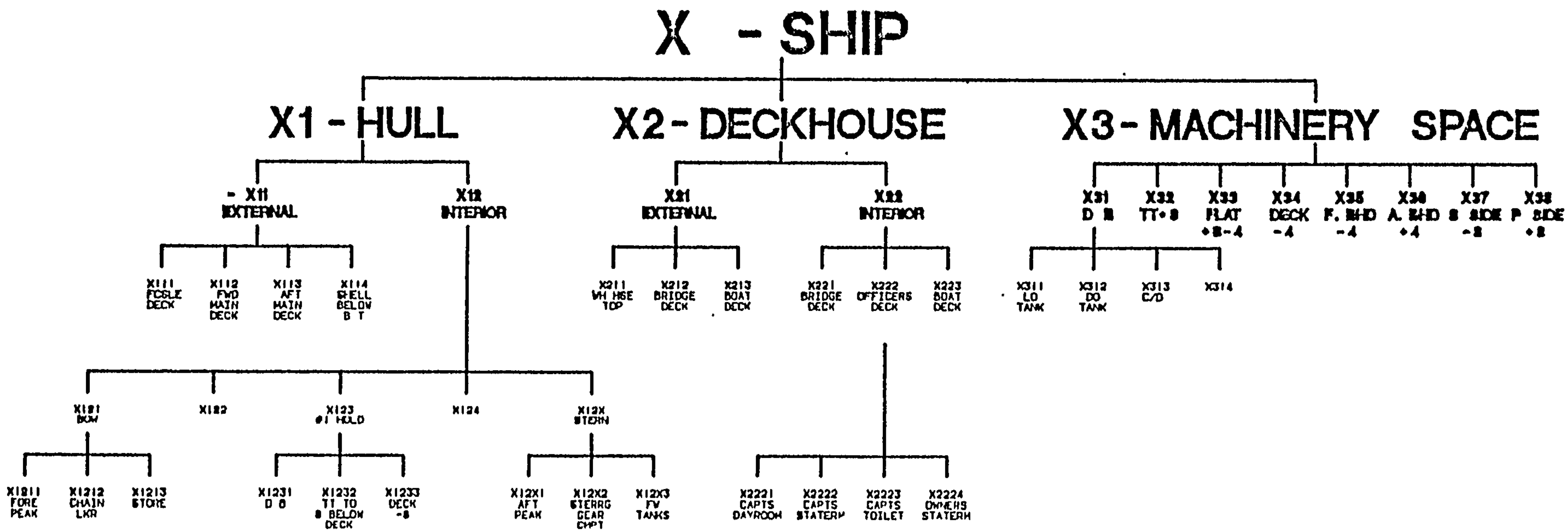


FIGURE 2 - HIERARCHICAL ZONE DESIGNATION SYSTEM

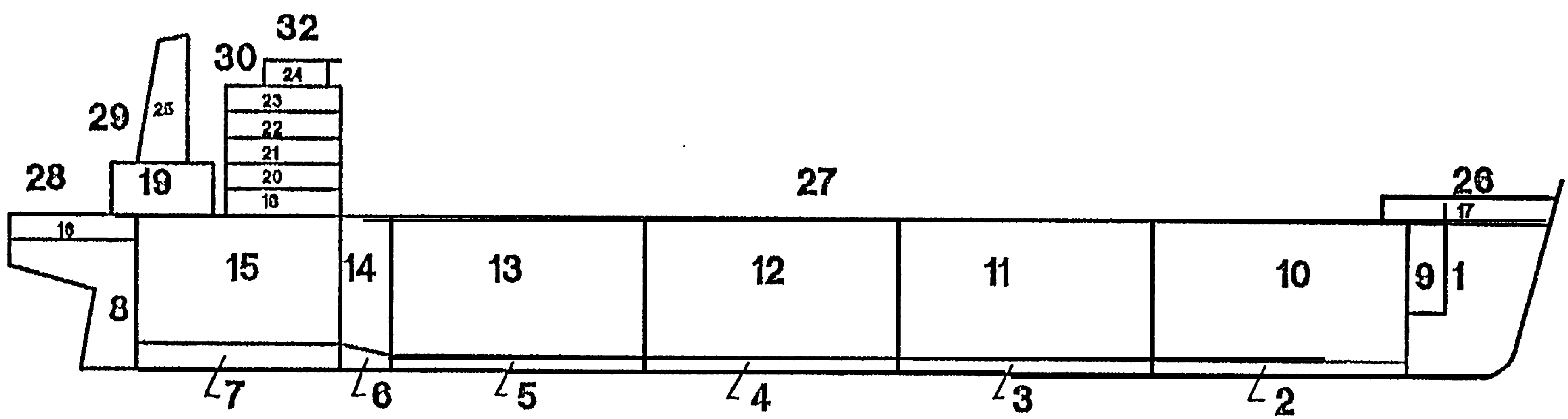
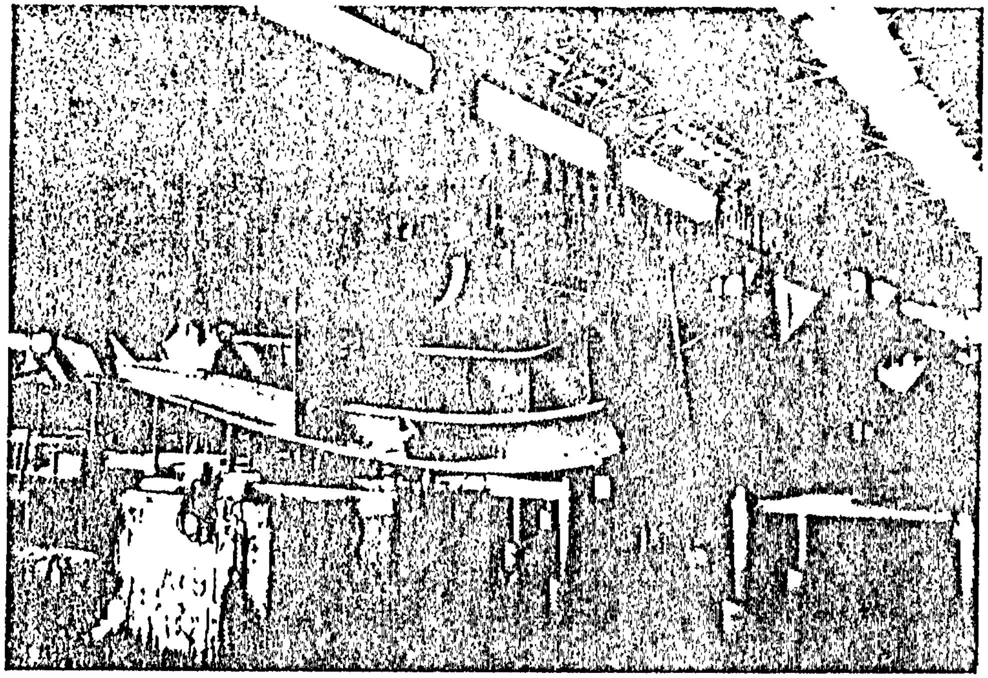


FIGURE 3 - SIMPLE SEQUENTIAL ZONE DESIGNATION SYSTEM



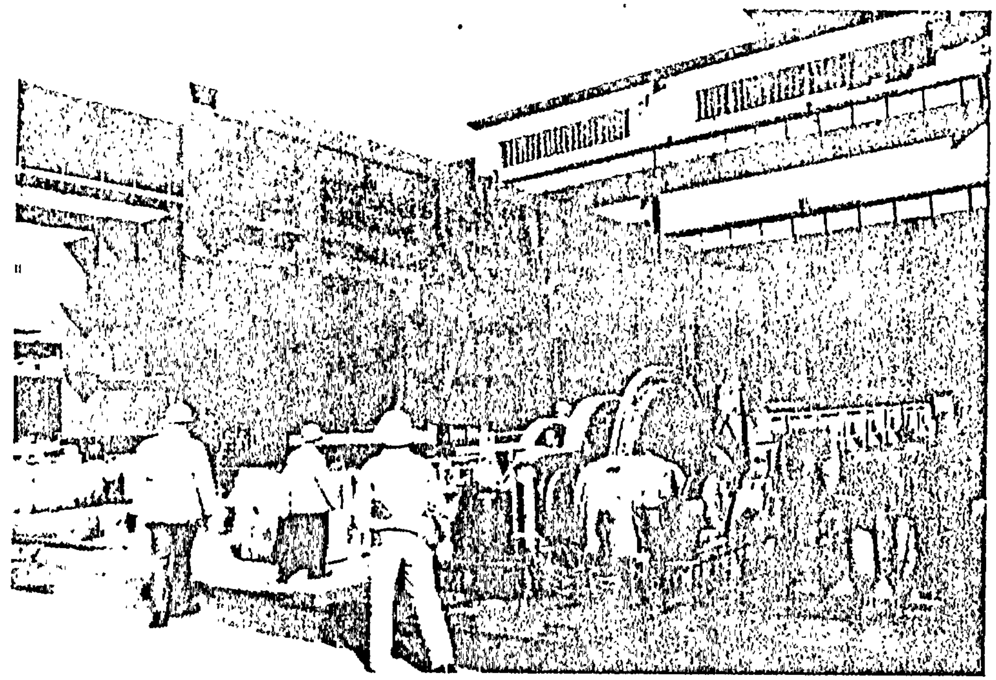
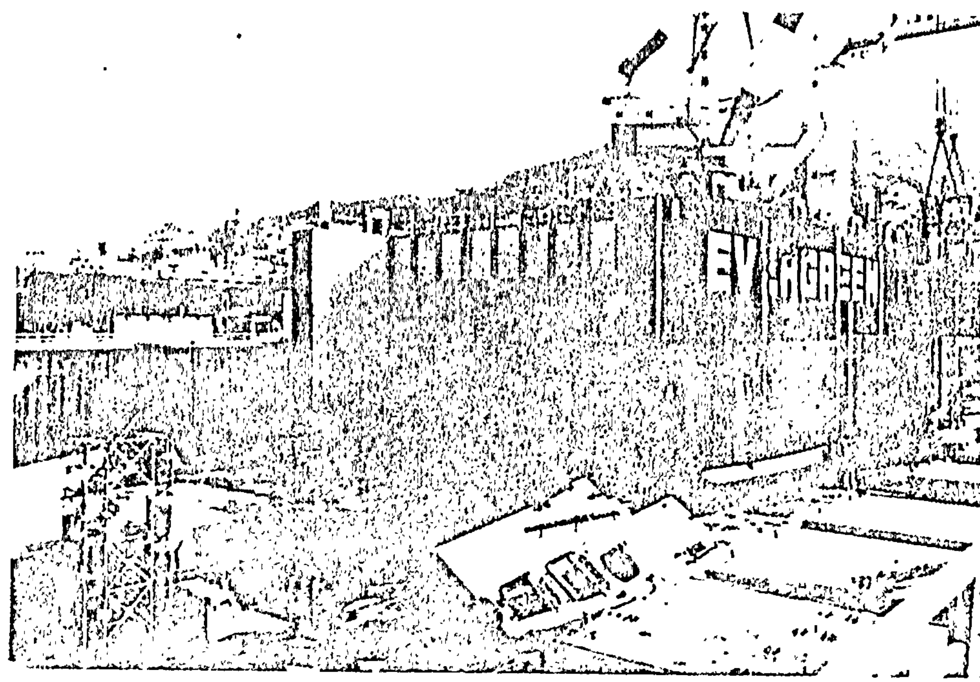
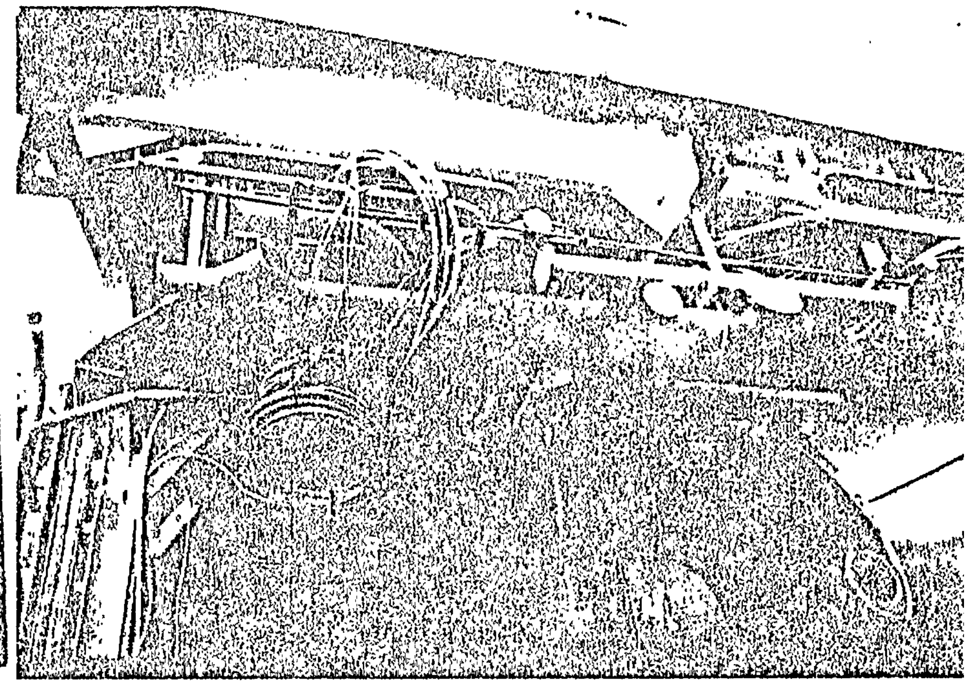


FIGURE 4 - STRUCTURAL MODULAR CONSTRUCTION OF SHIPS





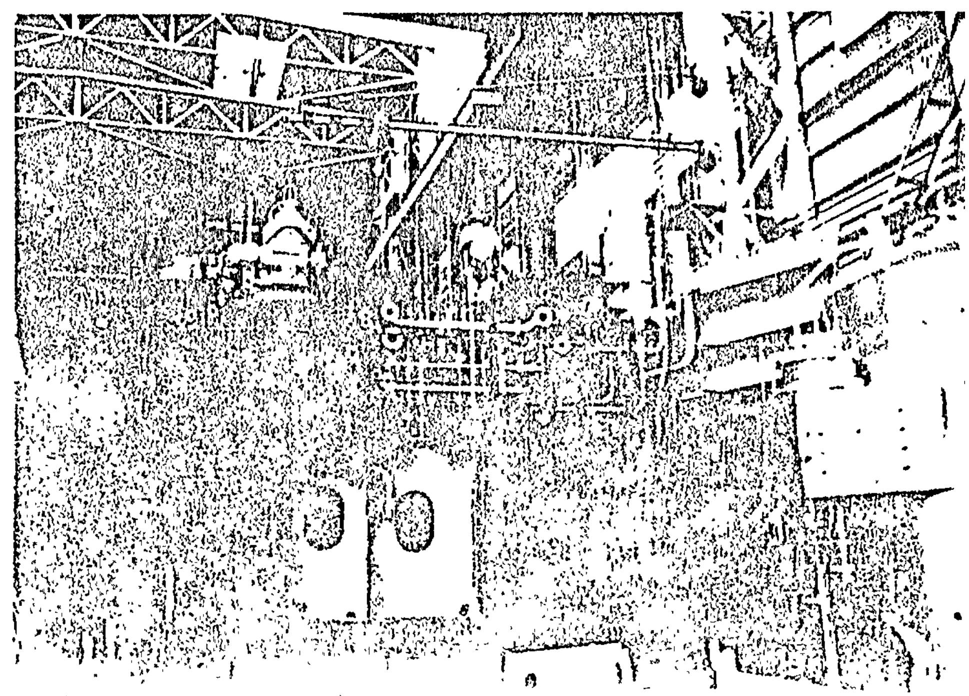


FIGURE 5 - ADVANCED OUTFITTING

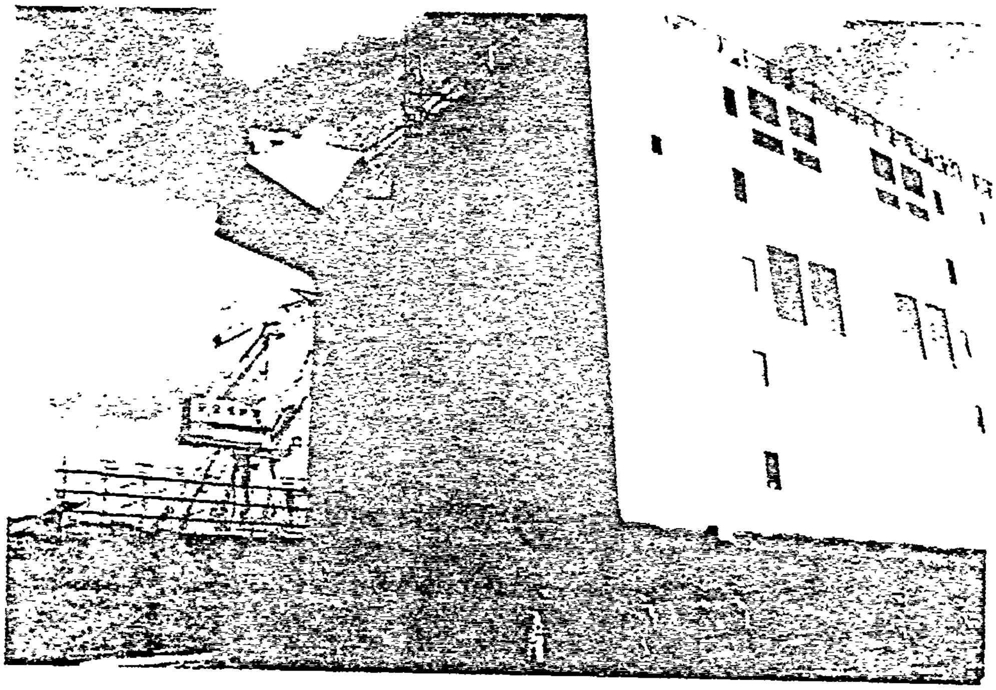


FIGURE 6

DECKHOUSE COMPLETED BEFORE ERECTION

3.0 ENGINEERING REQUIREMENTS FOR ZONE CONSTRUCTION

Zone Construction requires engineering information to be prepared in a different way and in a different sequence and schedule to the traditional approach. In order to understand the differences, it is necessary to review the traditional approach before defining the zone construction requirements.

Not, withstanding the fact that all engineering design should be prepared to be the best possible for production and thus the most cost effective, it seems that ship designers have not kept this in mind as the industry changed from craft to a process activity. Over thirty years ago, shipyards were craft organized and the various engineering groups as well as production groups tended to work in isolation from each other. The amount of detail shown on the engineering drawings was quite small as the craftsmen were expected to and were able to use their training and experience to develop details on the job. As long as ships were assembled on the building berth in many small individual parts, this system worked quite well. Productivity depended almost entirely on the effort and ability of the production craftsmen. When welding replaced riveting, two important changes took place. First, it required better accuracy in cutting and fitting parts, which provided the impetus to develop better lofting and steel processing through optical projection and then

computer aided lofting and computer aided manufacture. Second, it enabled structural pre-fabrication to take place in shops and platens away from the building berth.

Another significant event in ship production occurred during World War II when the U. S. was called upon to be the shipbuilder to the Allies. The techniques adopted at the multiple ship shipyards were geared toward mass production, and to overcome the use of inexperienced labor. Extensive prefabrication was planned into the design to allow an assembly line approach to be used. Simplified. engineering drawings were provided to the workers. Very detailed planning and scheduling of material receipt, processing and installation were used along with a highly developed production control of the construction processes. This was possible due to the repetitive processes performed at each work station. Erection panels of up to 50 tons were handled in some of the shipyards. At the end of the war, many shipbuilders closely examined the techniques developed in the U. S. shipyards and adapted them to their own facility, and in some cases improved on them, as in the case of the National Bulk Carriers shipyard in Japan and the impressive shipbuilding achievements in Japan and Europe in the 1960's.

Out of this era of noticeable change followed by the depressed shipbuilding market of the late 70's, the need for consolidation of facilities and ship production

techniques developed. Along with this came the clear need for ship designers to become cost conscious as they applied their talents to the design of future ships.

This must be accomplished by using the most efficient method of construction while still satisfying the many compromises resulting from conflicting requirements between the owner's desires, regulatory and classification rules, and the need to have a competitive edge over the other shipyards. However, many shipyard engineering departments continue to work in isolation, without taking into account the producibility of their designs.

Fortunately, it is possible to obtain significant increases in productivity in existing shipyards without large investments in plant and construction equipment by redefining the ship construction approach, and planning the construction of the ship at the same time as the preparation of the drawings, thus being able to influence the design to suit the intended building plan. This also required the engineering to be prepared to suit the construction approach.

Table I summarizes the major differences between Traditional and Zone Engineering along with the benefits of the latter. Figure 8 shows a typical design, engineering and production schedule for the Traditional approach and Figure 9 shows the same for Zone Engineering approach. By comparing the two approaches, it can be seen that the latter approach

enables the production department to commence construction earlier and to complete the ship in a shorter time than the Traditional approach. This is because the engineering information for the first Zone (module) is completed earlier than would be the many item drawings that the traditional engineering approach requires before construction could commence. This, in turn, enables the lofting, processing, assembly and outfitting of the module to occur earlier resulting in the shortening of the construction time.

The optimum engineering information transmittal format for Zone Construction is a drawing or sketch and part list for each workstation (including zones on board the ship). This is not only for structure but for all other systems. A work station drawing (sketch) shows all the work that occurs at one location, such as platten, shop, machine, module or zone. It can be one sheet showing the completed product at the end of all the work to be completed at a given work station with written sequence (process) instructions or it can be a series of sequential construction sketches showing the build up of the product from the received parts to its completed status for the work station.

Zone Construction requires engineering for all systems to be available at almost the same time as that for the structure. It also requires an integration of material

procurement with the development of the engineering for each zone so that the required material will be available as early as possible. This change in time of preparation of engineering data can be seen from Figure 10.

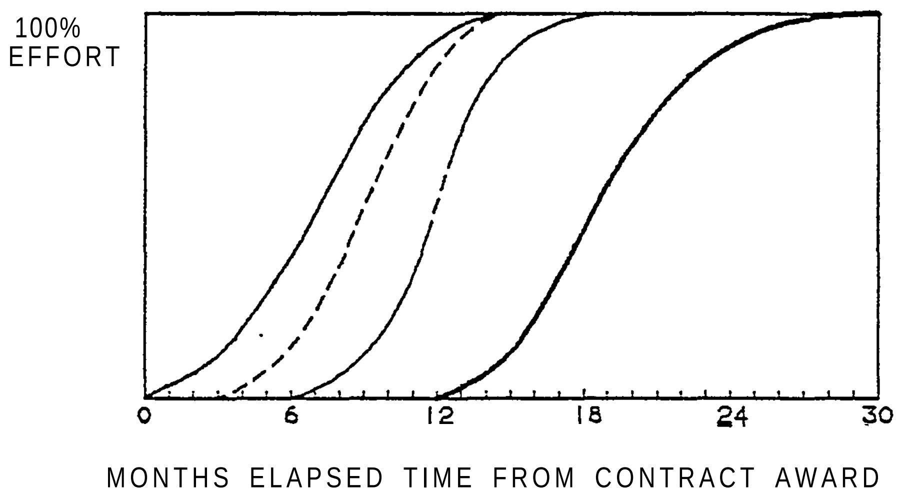
TABLE 1 - COMPARISON OF TRADITIONAL AND ZONE ENGINEERING

ENGINEERING

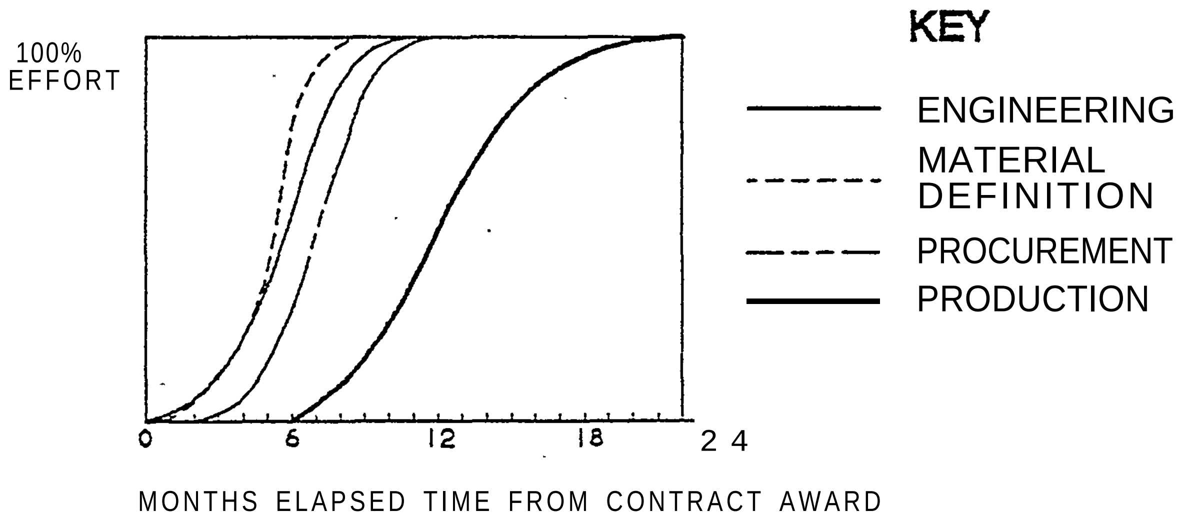
TRADITIONAL	ZONE	BENEFIT
Structural drawings prepared on item basis from bow to stern, e.g., - Shell drawing - Deck drawing - Bulkhead drawing - Tank top drawing - Framing drawing	Structural drawings prepared on a construction sequence basis for subassemblies, assemblies and blocks, e.g., - Web frame subassembly - Transverse bulkhead assembly - Double bottom block - Wing tank block	1. With traditional approach, construction cannot be started until a number of item drawings are complete. For example, one block required 13 drawings to show necessary data. With zone approach, construction can commence when the first block drawing is complete. 2. With traditional approach, it is necessary for someone (Production Planning) to prepare block parts lists and sequence assembly sketches. With zone approach, production can use engineering-prepared drawings directly, thus saving additional effort and time.
Machinery arrangements laid out for individual equipment and piping installation.	Machinery arrangements laid out for "OnUnit" advanced outfitting packages and piping and grating package assemblies.	"On Unit" advanced outfitting has been demonstrated to be the greatest productivity improver. Also allows work to be performed on unit and the ship to be completed earlier.

TRADITIONAL	ZONE	BENEFIT
System diagrammatics prepared for design use only in preparation of A&D drawings with no particular accuracy in equipment location or pipe routing.	System diagrammatics prepared accurately as possible including scheming for pipe routing with other system5 and showing all information required for material procurement and planning.	1. By integrating all system diagrammatics in a given space, the grouping for piping of various systems can be considered. 2. Also, knowing that the diagrammatics are more accurate allows material to be ordered with greater confidence which reduces the need for margins. 3. More complete diagrammatics are acceptable for complete owner and classification approval, i.e., it is not necessary to send A&D drawings for approval.
A&D system drawings prepared for complete ship or areas of ship without regard to block breakdown or "On Unit" advance outfitting. Usually prepared as independent drawings for each system, thus making integration and grouping of piping and supports together for installation difficult, if not impossible.	System working drawings consist of final instructions to the production worker, such as spool sheets, installation sketches and material lists suitable for direct incorporation in work packages.	1. Elimination of traditional A&D system drawings. 2. Earlier availability of construction information for piping. 3. Prepared on a zone basis, earlier installation of piping. 4. Eliminates current additional step which can introduce human error which can mushroom due to unexpected interferences and/or rework.

TRADITIONAL	ZONE	BENEFIT
Engineering drawings, data, etc., that are unsuitable for direct issue to Production, must be further processed by Production Planning.	Engineering prepares all production-required drawings and data, such as structural sub-assembly, assembly and block sequencing sketches, pipe spool sketches, advanced outfitting drawings and lists,	1. Increase in mutual engineering/ production knowledge and cooperation. 2. More problems solved on paper rather than on hardware.
No input for advanced outfitting.	Prepares advanced outfitting drawings and parts lists.	1. Engineering designs ship to facilitate advanced outfitting. 2. Forces material definition to support advanced outfitting. 3. Results in a more integrated ship.
Lofting is prepared from and therefore after detailed structural drawing is completed.	Lofting is an integrated part of structural development. Usual detailed drawings eliminated.	1. Shortened time from contract award to cutting steel. 2. Increased productivity of combined engineering and lofting.
Independent planning and scheduling keyed to a master event schedule.	Integrated planning and scheduling for Engineering, Materiel procurement, and Production for individual work packages.	1. Compatibility of all detailed schedules. 2. Effect of change on one department automatically apparent to other departments. 3. Schedule items identifiable to simplest production package.



TYPICAL TRADITIONAL
PERFORMANCE SCHEDULE



REQUIRED SHORT BUILD CYCLE/
PERF0RMANCE SCHEDULE

FIGURE 7 - COMPARISON OF TRADITIONAL AND COMPETPTIVE CONSTRUCTION SCHEDULES

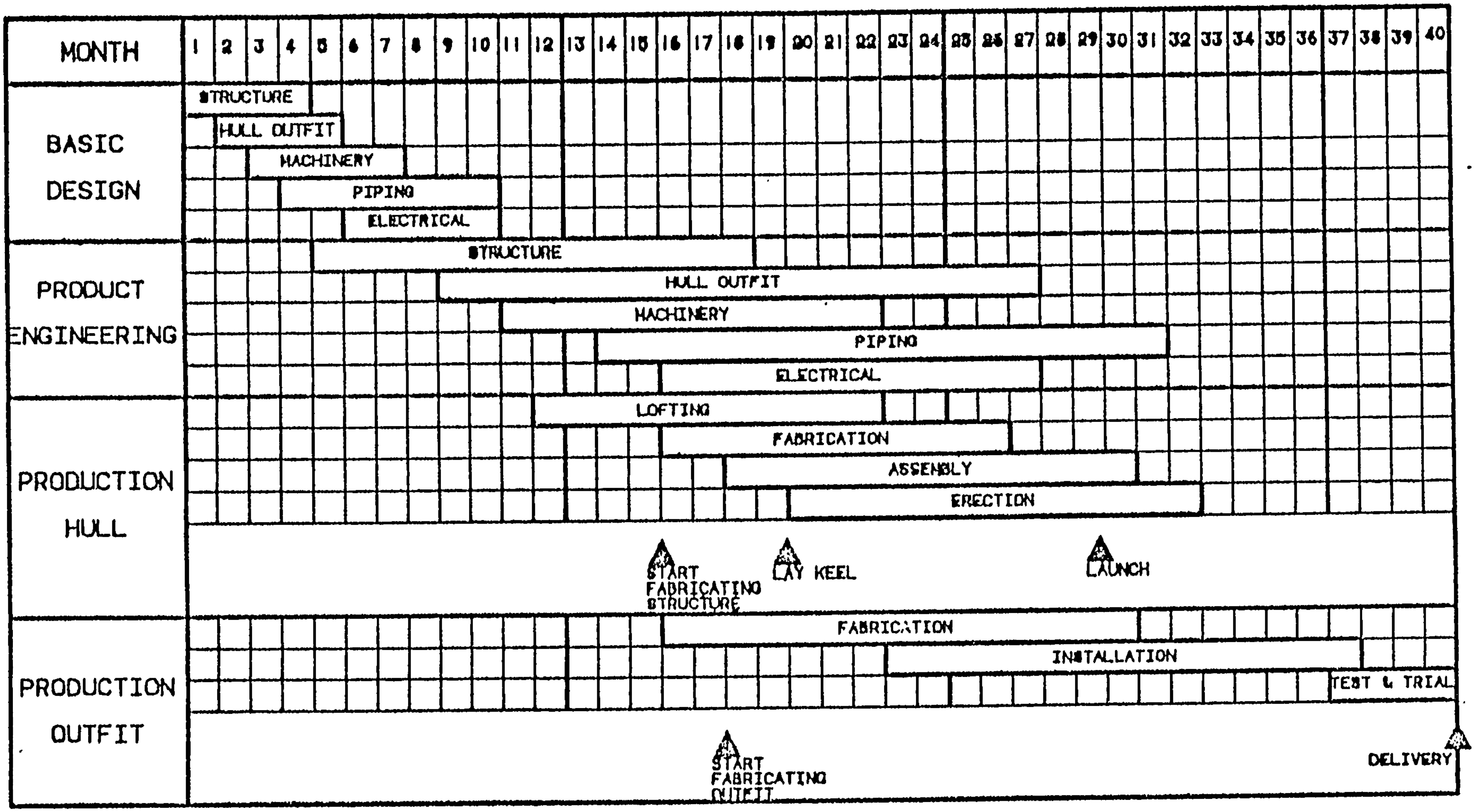


FIGURE 8 – TRADITIONAL SHIPBUILDING AND ISOLATED ENGINEERING

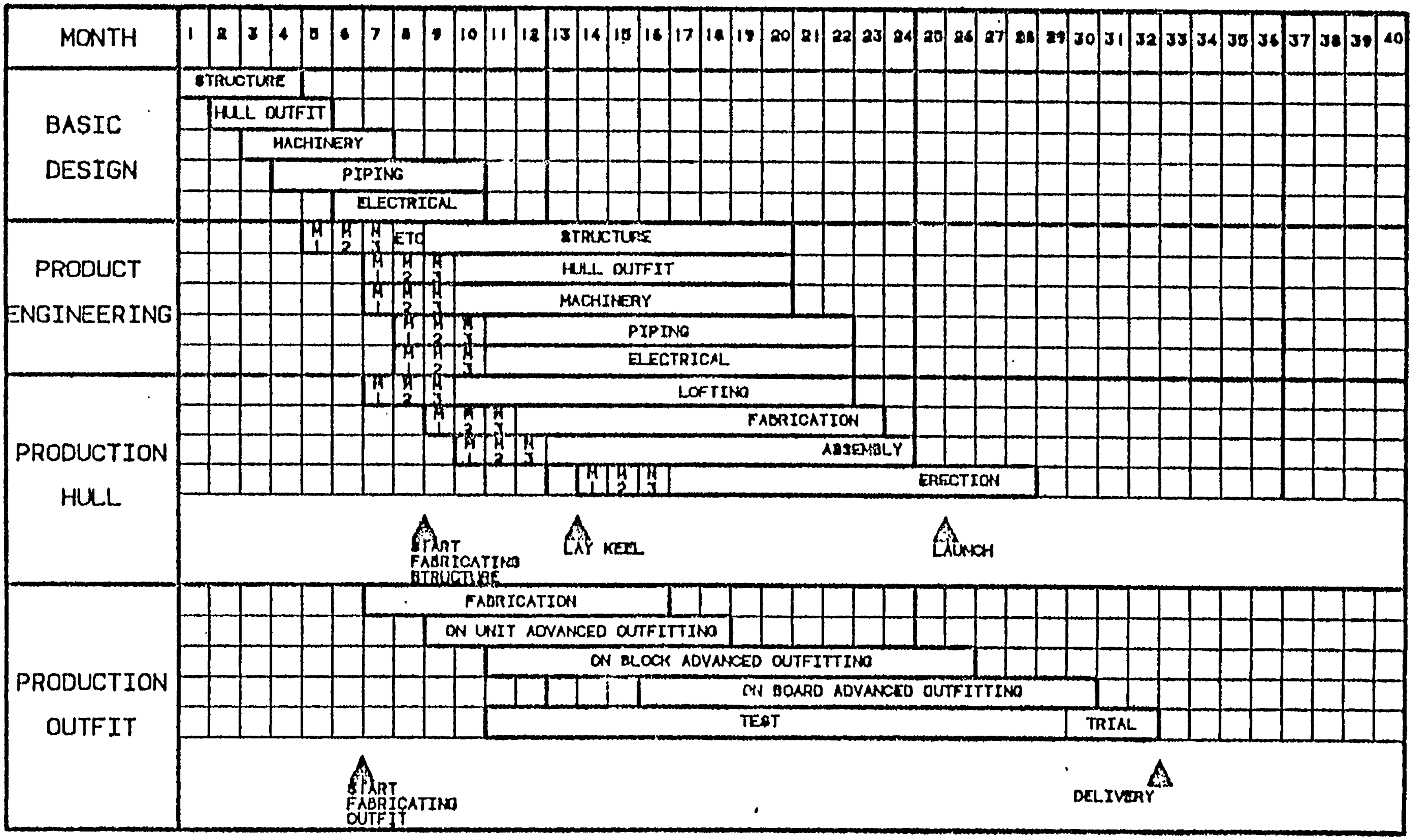


FIGURE 9 -ADVANCED SHIPBUILDING AND INTEGRATED ENGINEERING

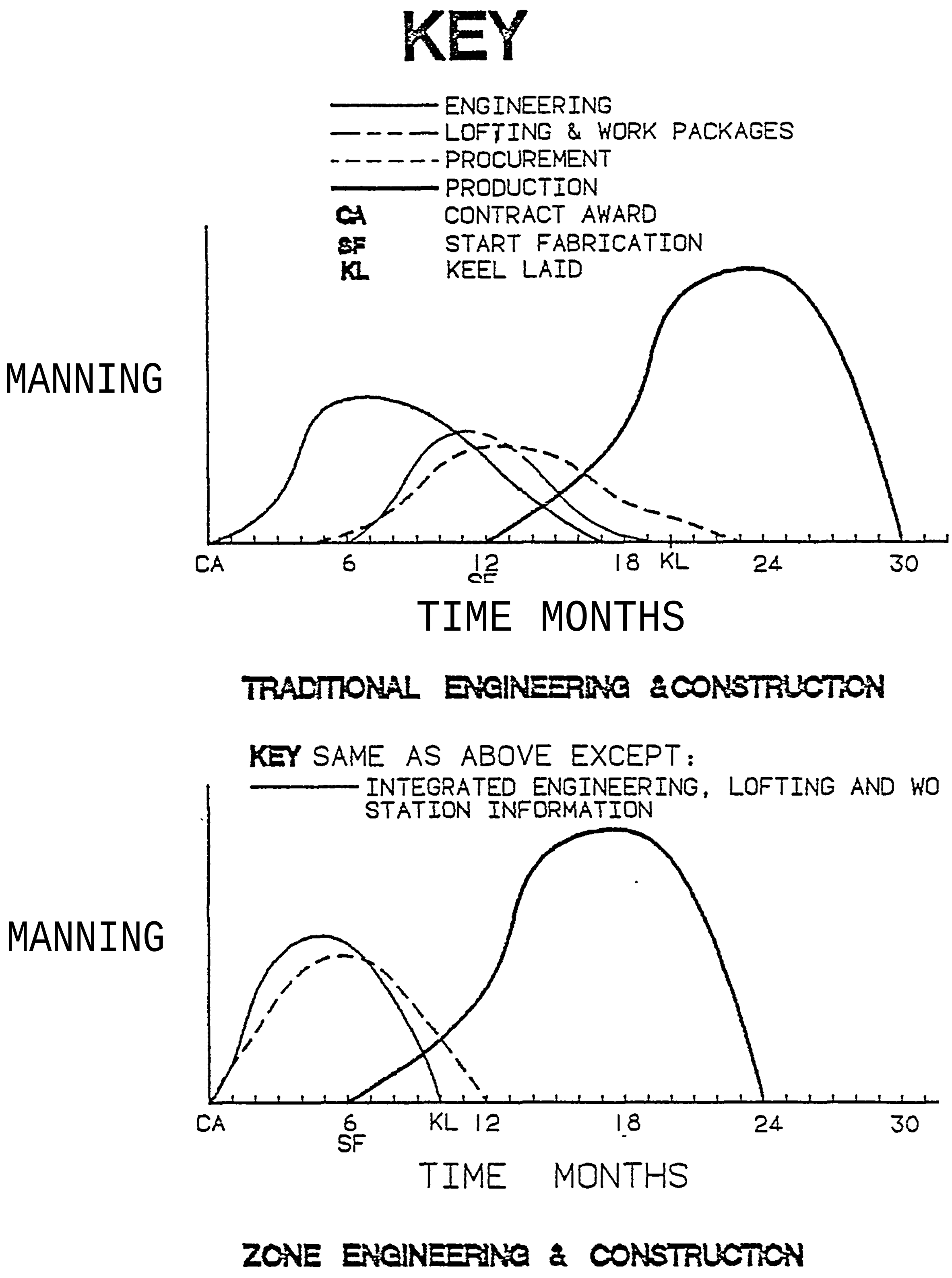


FIGURE 10 - COMPARISON OF MANNING SCHEDULES
FOR TRADITIONAL AND ZONE CONSTRUCTION

The design engineering process can be conveniently divided into BASIC DESIGN and PRODUCT ENGINEERING as shown in Figure 11.

Basic Design covers all design from conceptual through to system, quantity and material design. This process has again been conveniently divided into Concept, Preliminary, Contract and Functional Design. All but the last must be performed before\-, the award of a construction contract. Functional Design is the phase where the Contract Design is expanded to contain all design decisions. Table 2 lists typical Functional Design tasks.

Product Engineering covers all tasks required to transmit construction information to Production, and other shipyard departments. It again is divided into two phases. The first, Transitional Design, is the task of integrating all design information into complete zone detailed arrangements. The second, Work Station/Zone Information Preparation, is the task of providing all drawings, sketches, part lists, process instructions, production aids (such as N/C tape) required by Production and other service departments to construct the ship. Table 3 lists typical Work Station/Zone Information Preparation tasks.

Obviously, this approach to engineering will require additional manhours to accomplish it. However, as shown in Figure 12 the overall result of Zone Construction is a reduction in <u>total</u> manhours to design, engineer, plan and construct a ship.

BASIC DESIGN				PRODUCT ENGINEERING	
CONCEPT DESIGN	PRELIMINARY DESIGN	CONTRACT	FUNCTIONAL	TRANSITIONAL	WORK STATION/ZONE INFORMATION

CONTRACT AWARD

FIGURE 11 - PHASES Of ENGINEERING FOR ZONE CONSTRUCTION

TABLE 2

FUNCTIONAL DESIGN

HULL

General Arrangement

Outboard Profile

Lines

N. A. Drawings

Structural Module Drawings

Major Foundations

Weights, Centers and Lifting Data

Lists of Hull Outfit

Lists of Hull Fittings

Nameplates and Notices

Summary Painting Schedule

Summary Deck Covering Sequence

Summary Hull Insulation Schedule

Furniture List

Plumbing and Fixture List

Galley Arrangement

Accommodation Arrangement

Steering Gear Arrangement

Rudder and Rudder Stock Arrangement

Rudder and Propeller Lifting Gear Arrangement

Anchor Handling Arrangement

Mooring Arrangement

Life Saving Equipment Arrangement

Hull Piping System Diagrams

Purchase Technical Specifications

TABLE 2

FUNCTIONAL DESIGN

HULL - Continued

Advanced Material Ordering Lists

Steel List per Module

MACHINERY AND PIPING

Machinery Arrangement

Shafting Arrangement

Stern Tube Arrangement

M/C Space & Wheelhouse Control Console Arrgt.

Machinery Piping System Diagrams

Diesel Exhaust Arrangement

Lifting Gear in M/C Space

M/C and Pipe Insulation Schedule

ELECTRICAL

Electrical Load Analysis

One Line Diagram

Short Circuit Analysis

List of Motors and Controllers

List of Feeders and Mains

Electrical E &I Diagrams

List of Portable Electrical Equipment

HVAC

Heating and Cooling Analysis

HVAC Diagram and Equipment List

TABLE 2

FUNCTIONAL DESIGN

HVAC - Continued

HVAC Insulation Schedule

TABLE 3

WORK STATION/ZONE INFORMATION

A. For Structure - Work station information consisting of:

- Sequenced isometric construction sketches and part lists for subassemblies.
- Sequenced isometric construction sketches and part lists for assemblies.
- Sequenced isometric construction sketches and part lists for modules.
- Sequenced isometric construction sketches and part lists for module erection.

B. For Piping - Pipe assembly sketches and part lists. Sequenced pipe installation sketches and part lists for A/O units and zones.

C. For HVAC - Duct assembly sketches and part lists. Sequenced installation sketches and part lists for equipment and ducting.

D. For Machinery - Sequenced installation of equipment (in conjunction with piping, electrical, HVAC) for A/O "On Unit", "On Block", "On Board", and Zones.

E. For Electrical - Cableway installation for each module/zone including part lists. Cable lengths and numbers per section for each module/zone. Equipment installation sketches and part lists for each module/zone.

F. Hull Outfit - Sequence installation sketches and part lists for mooring fittings, doors, windows, ladders, handrails, paint, insulation, joiner work, deck coverings, deck machinery, furniture, galley equipment, provision store rooms, etc., for zones.

TABLE 3 - Continued

G. <u>For Advanced Outfitting</u> - Sequenced construction and installation sketches and part lists for foundations, grating, floor plates, equipment, pipe, electrical, and hull outfitting joiner work and furniture for units, modules-and zones.

All the above work station/zone information will be designated for either Hull, Deckhouse or Machinery Space grouping. There shall be no overlap of one group into another group's area to complete engineering work scope.,

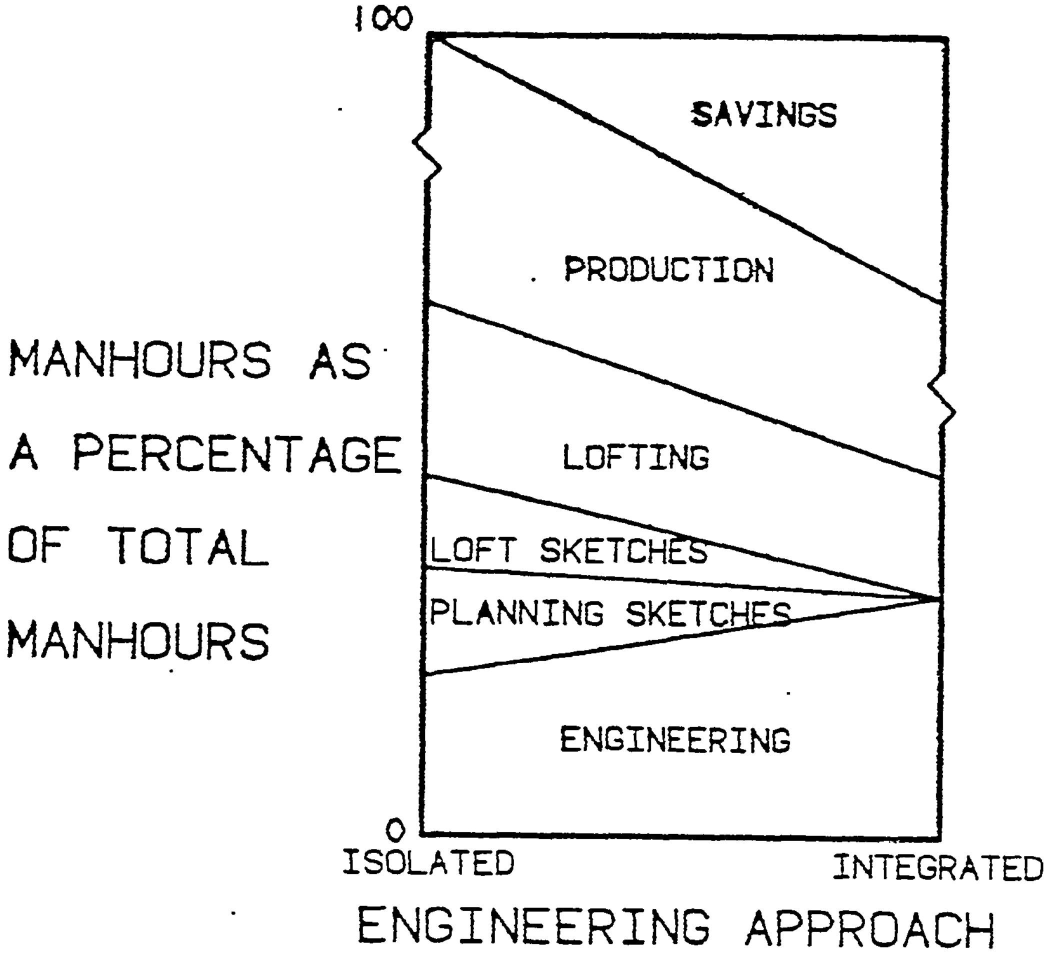


FIGURE 12 - OVERALL PRODUCTIVITY BENEFIT OF ENGINEERING FOR ZONE CONSTRUCTION

4.0 ENGINEERING ORGANIZATION FOR ZONE CONSTRUCTION

Organizational Theory has steadily developed along with the better understanding of human relations, motivation and worklife sciences. That this is so, is clear from a review of any bibliography on the subject of organization. It is not the intent to describe or recommend any of the theories, especially as the very foundations have been discredited in recent books about the most successfully operated U. S. companies (5) and future trends (6). What will be discussed is the basic organizational requirements for a shipyard engineering department. A number of papers and reports (7, 8, 9 and 10) touch on engineering organization, but only the later ones do so in any depth or cover the reasons for the differences. Books on general technical or engineering management (11, 12 and 1.3) describe some organizational aspects which can be helpful when examining shipyard engineering organization. The more recent papers and reports on advanced shipbuilding technology all contain three basic principles for shipyard engineering organization, namely;

1. Shipyard engineering should be divided into BASIC DESIGN and PRODUCT ENGINEERING. The meaning of this breakdown can be seen in Figure 13.

2. Engineering information should be presented in the simplest and most effective manner.

3. Engineering information should be developed to transmit only the information needed by one or more workers at a specific work station to perform the work at that work station.

To these three should be added a fourth, namely;

4. Engineering and planning are synonymous and the Product Engineering Section should prepare all planning material, such as lofting, N/C processing data, pipe sketches, instruction sheets.

The reasons for this additional principle should be obvious to the readers of this paper. It connects together the logical sequencing of the same data and with the increasing use of computers and software for CAD/CAM, it is possible to generate all the planning material as a natural fallout from the engineering data base.

Before proceeding, it is necessary to review some of the well known organizational structures. These include:

- Function
- Product
- Process
- Customer
- Matrix

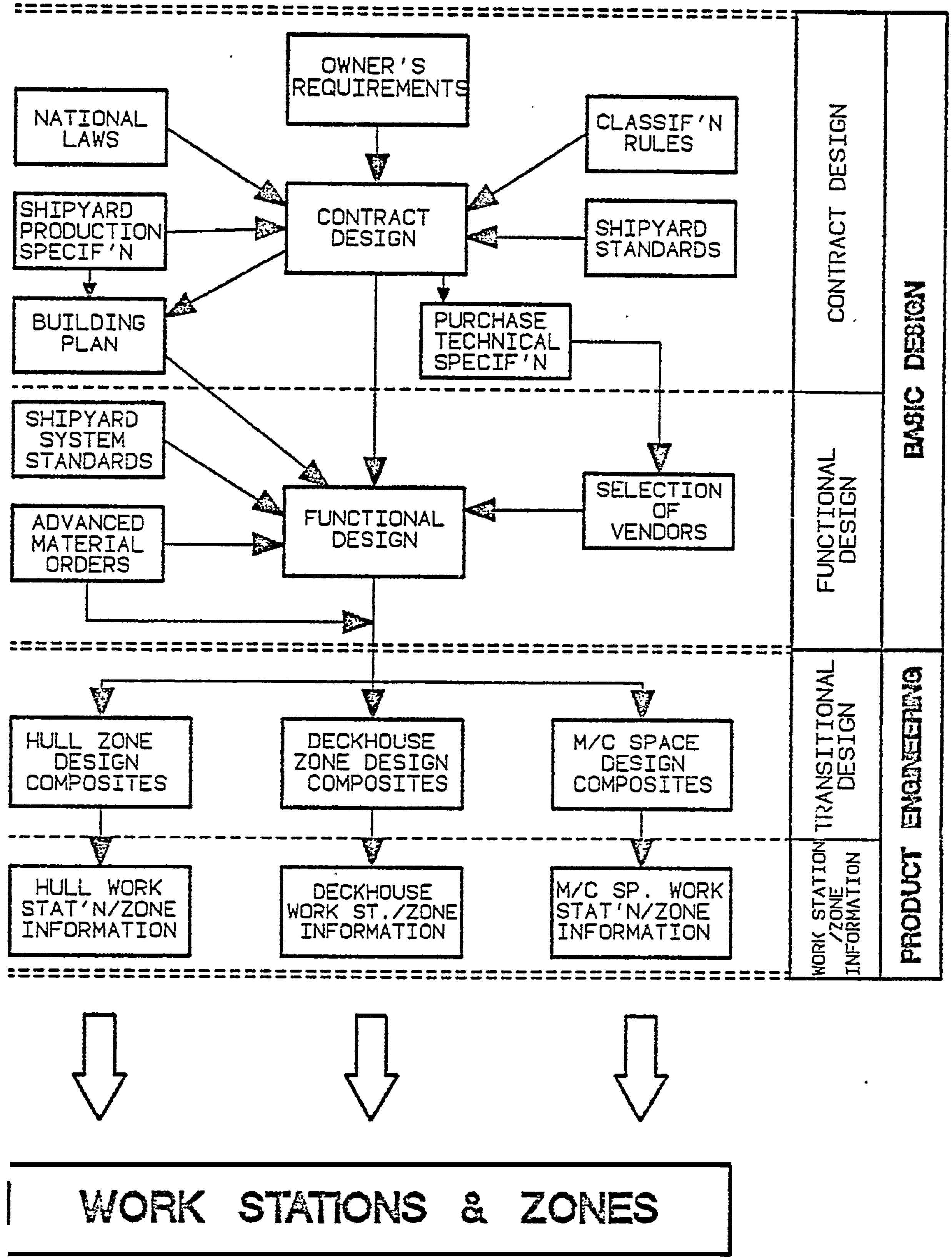


FIGURE 13 - FLOW OF DESIGN AND ENGINEERING INFORMATION

A Functional Organization is separated into major departments on the basis of function, such as Production, Engineering, Marketing, Finance, etc. This is the most common type of organization structure, as most people are educated and trained by function, and also organizations tend to copy other organizations. Such an organizational structure is shown in Figure 14.

The Product Organization is divided into divisions on the basis of major products, such as cars, trucks and tractors. Figure 15 shows a typical Product Organization. Product Organization has been used for the Product division of many large manufacturing companies.

Some manufacturing companies have found it beneficial to use an organization structure which fits in with the various processes through which their work moves, thus the name Process Organization for which a typical structure is shown in Figure 16.

Service companies often utilize a Customer organization structure. This type of structure is suited to sales oriented divisions or departments such as Marketing. A typical organization is shown in Figure 17. The usual reason for adopting this type of organization structure is to ensure that the needs of each customer are more than adequately met, and to give the appearance of special individual attention.

The Matrix Organization structure, which is shown in Figure 18, developed from the attempt to combine the benefits of more than one of the above types. This type of organization was utilized extensively by defense contractors. In its most common form, the Matrix organization provides the manager with the benefits of both the function and product (project) organization types.

The most recent trend is for shipyards to utilize the Product organization structure, but with the product being main zones of each ship. Obviously, the most benefit will result if all departments are organized in the same way. Much of the current problems are due to the fact that departments within the same shipyard have different organization structures, and the resulting mismatch of personnel in them. For example, it is not uncommon to find engineering functionally organized, purchasing product organized, planning process organized, and production functionally organized. This has to be changed to achieve high productivity shipbuilding. It is also necessary for all departments to be organized in the best way to support the production department.

The MarAd/SNAME sponsored IHI Shipbuilding Technology books lead from Outfit Planning to Design for Zone Outfitting. They develop a very specific approach to engineering organization which basically follows their overall

production organization. This is shown in Figure 19. Figure 20 shows a typical U. S. shipyard engineering department organization and Figure 21 the same for a British shipyard. It is interesting to note that the British organization is basically a two zone type. The Ship section handles and integrates everything outside of the machinery space, which is handled by the Machinery section. However, Electrical is still handled for the total ship. This approach is also used by at least one of the successful, large Japanese shipbuilders. However, in the British shipyard, even though engineering was somewhat product (zone) organized', the Production department was still functionally (craft) organized. The U. S. shipyard engineering organization is functionally organized with the different disciplines working in all areas. As such, it has little to recommend it for improved shipbuilding technology.

Therefore, what should be the organizational structure for the future in U. S. shipyards? It is suggested that it should not be the MarAd/SNAME IHI type. This is because the IHI approach is not "pure" in that it mixes organization types such as functional, product and process structure with zones. This can be seen from Figure 22 which shows that even though Hull Block Construction, Painting and Electrical are involved in all three zones, they are organized independently, and in a different way to the desired zone

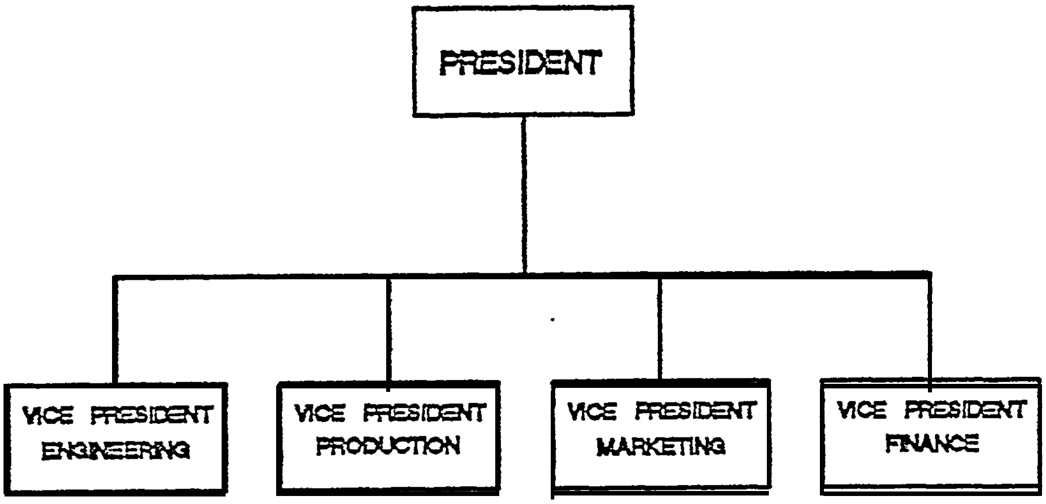


FIGURE 14 - FUNCTIONAL ORGANIZATION STRUCTURE

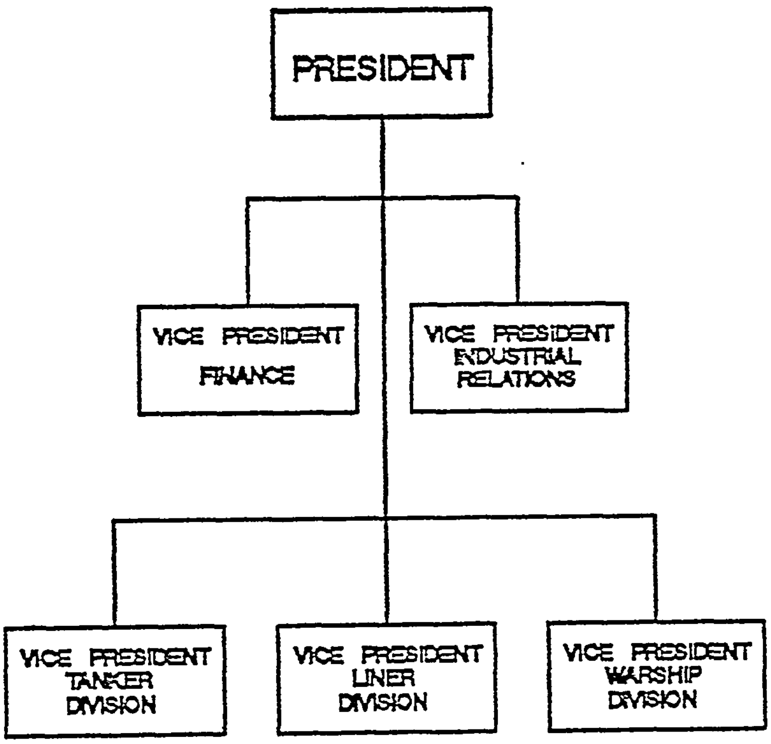


FIGURE 15 - PRODUCT ORGANIZATION STRUCTURE

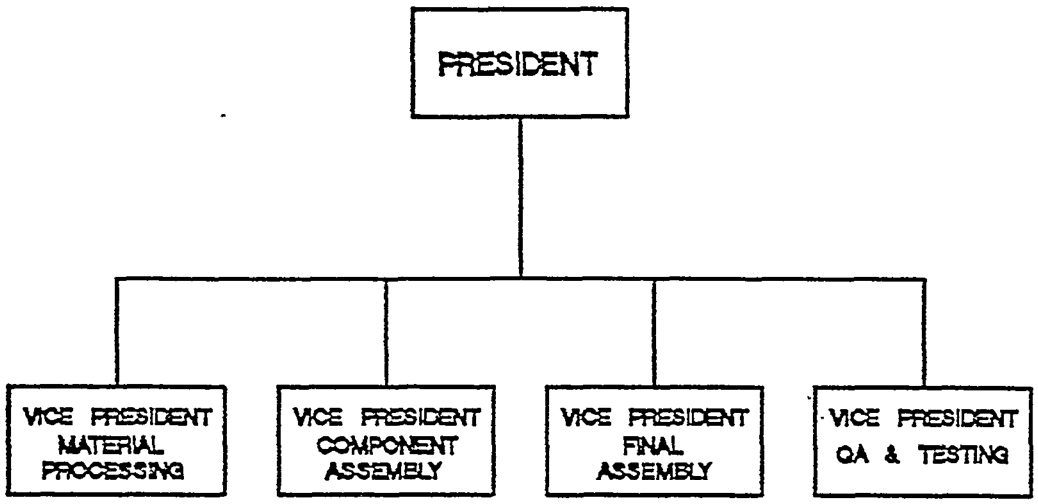


FIGURE 16 - PROCESS ORGANIZATION STRUCTURE

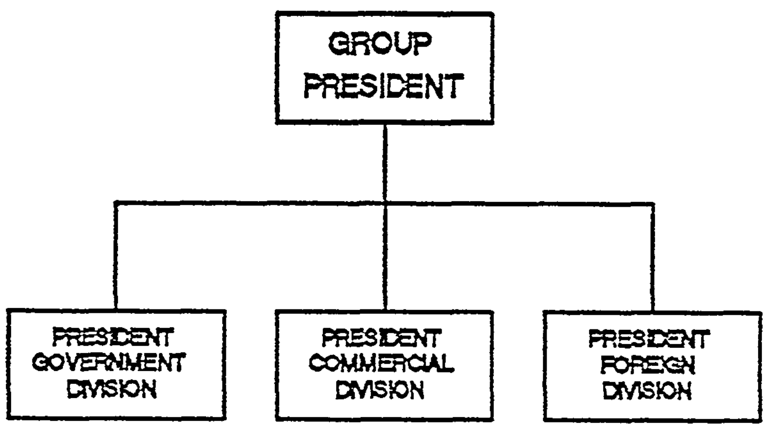


FIGURE 17 - CUSTOMER ORGANIZATION STRUCTURE

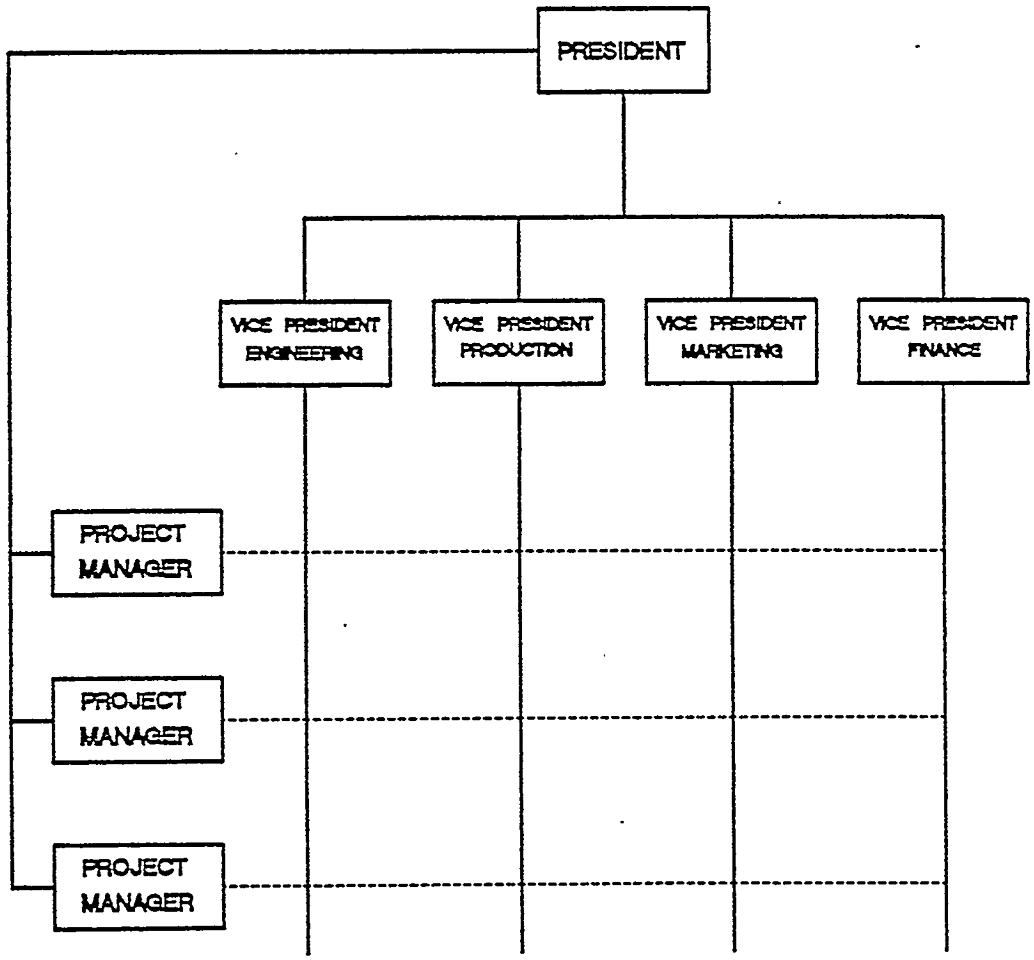


FIGURE 18 - MATRIX ORGANIZATION STRUCTURE

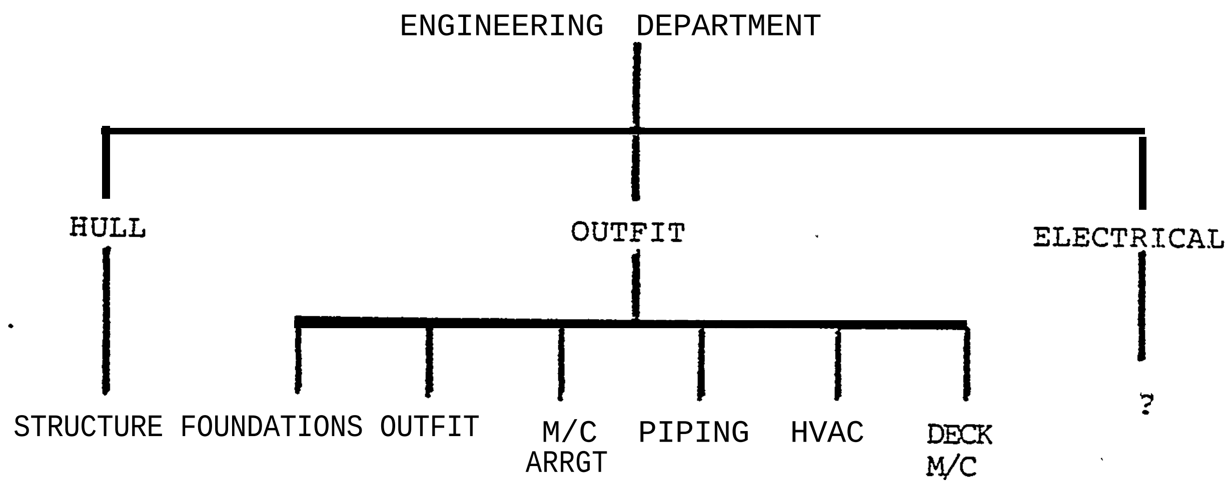


FIGURE 19 - MARAD/SNAME/IHI ENGINEERING ORGANIZATION

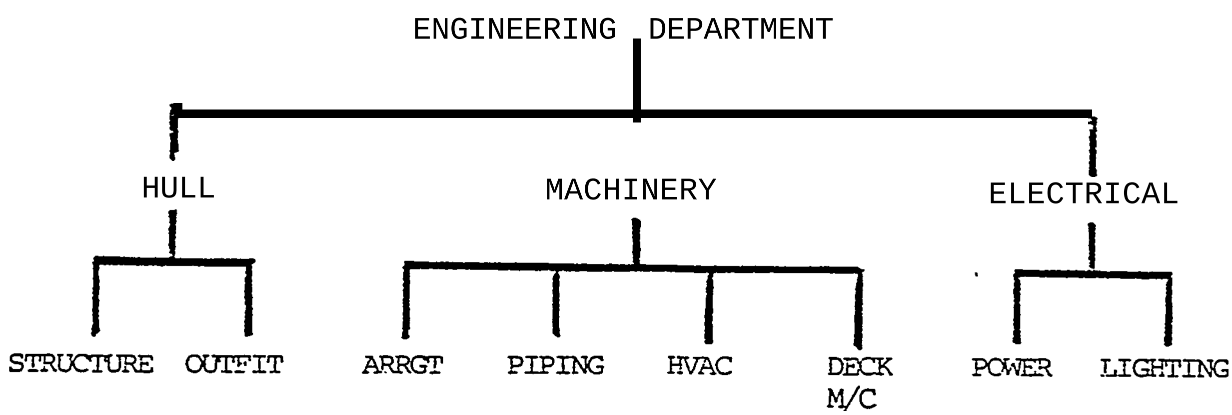


FIGURE 20 - TYPICAL U.S. ENGINEERING ORGANIZATION

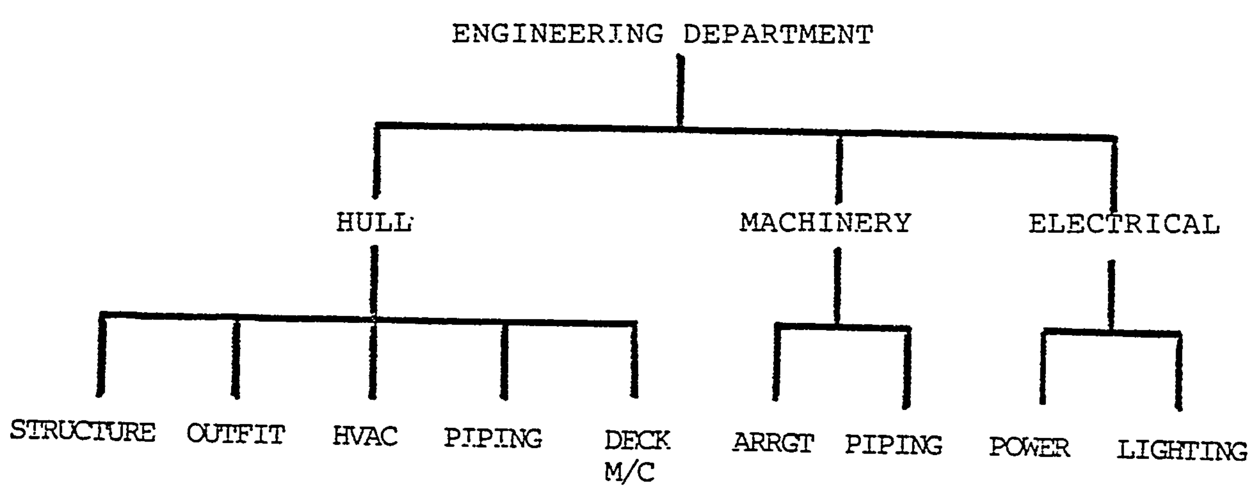


FIGURE 21 - TYPICAL BRITISH ENGINEERING ORGANIZATION.

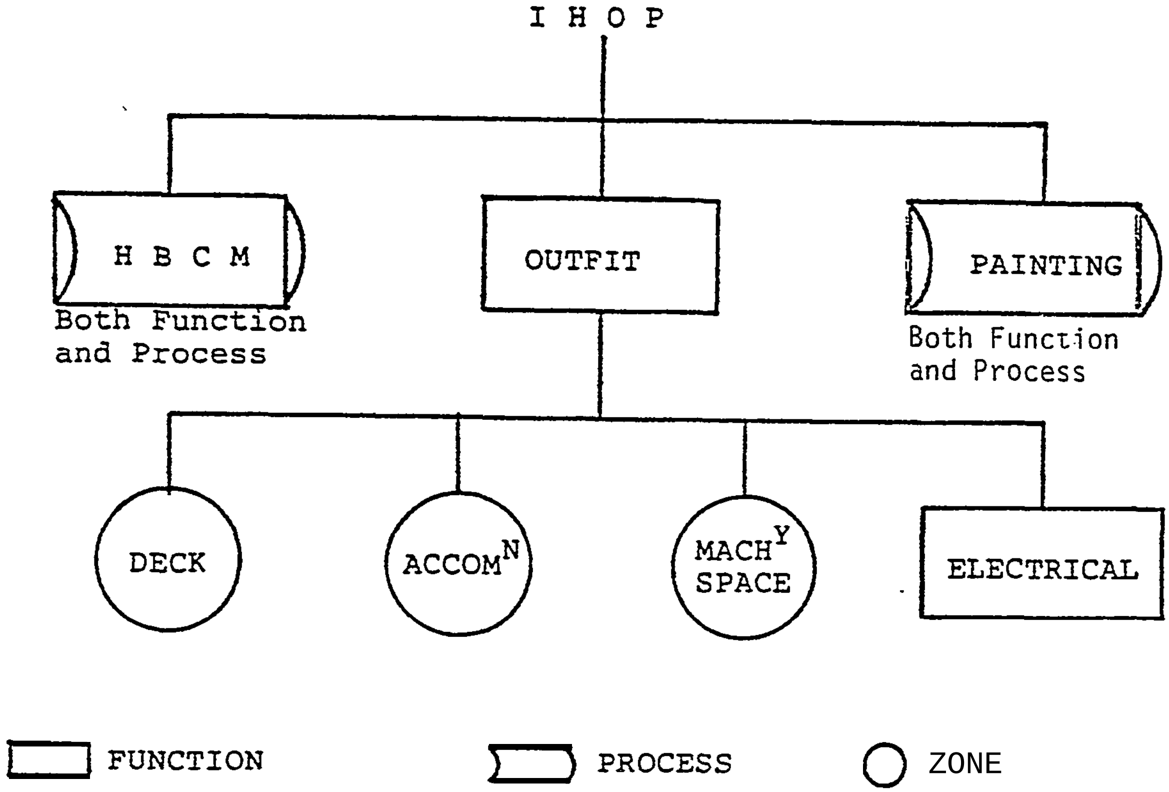


FIGURE 22 I H O P ORGANIZATION

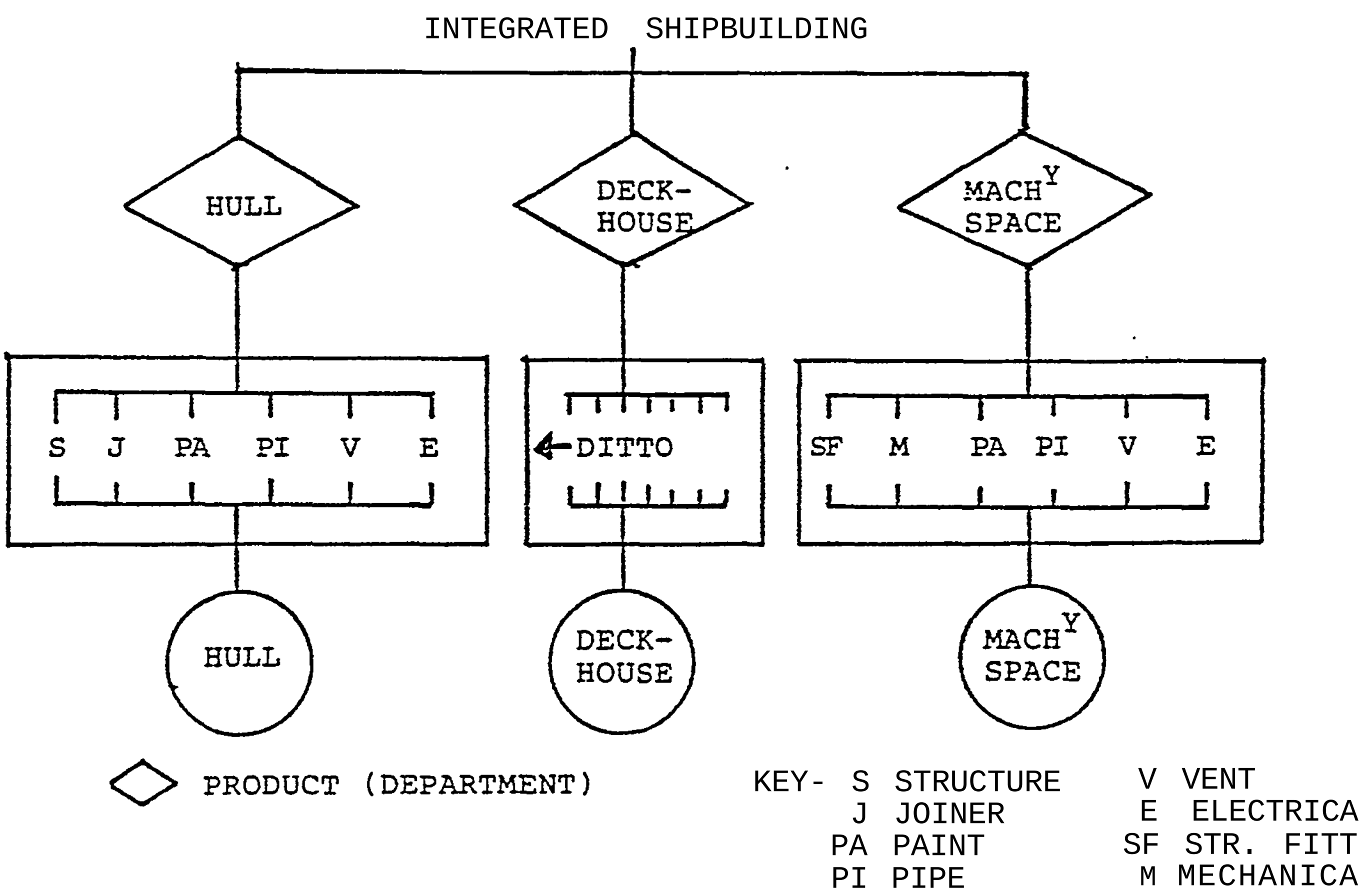


FIGURE 23 SUGGESTED ORGANIZATION FOR ZONE SHIPBUILDING

treatment of outfit. It can also be seen that Electrical, which is a function, is treated at the same level as the zones giving the D-A-M-E approach to outfitting. The inclusion of the "E" for Electrical has no organizational basis for being linked in this way to the three zones. It is suggested that it is done simply because of tradition in some Japanese shipyards. In order to develop an engineering organization, it is necessary to first develop the production organization with which it must blend. For this reason, a hypothetical production organization is shown in Figure 23. It can be seen that there is no incompatible mixing of organization structures, and that it is based on a three zone concept, namely; Hull, Deckhouse, and Machinery Space. Each zone covers a basic product even though each product is constructed from similar interim products. There is duplication of crafts within the three departments which is beneficial as long as there is a backlog of work to keep them all busy, and could lead to a restructuring of crafts in the future to improve their total performance in leaner and more competitive times.

It is obvious that an organization cannot be designed is the function of the parts are undecided. Therefore, the first step in engineering organization design is to establish the objectives of the Engineering Organization. This will depend on whether or not any part of the design and engineering will be performed by marine design consultants.

Based on the proposed Engineering for Ship Production approach, the objectives for a complete in-house engineering department include:

BASIC DESIGN

- o Perform concept, preliminary and contract design
- o Provide technical data for estimating and planning
- o Provide all design support for new ship construction
- o Provide Production Engineering
- o Prepare all design drawings through key drawings and diagrammatic phase
- o Prepare weight calculations
- o Provide Systems Engineering
- o MEET ALL ACCEPTED SCHEDULES

PRODUCT ENGINEERING

- o Organize to best support Integrated Shipbuilding
- o Prepare drawings, material lists, lofting, layouts, pipe assembly drawings and other Production required information
- o Perform configuration control of all engineering information
- o Provide engineering liaison to Production Department
- o MEET ALL ACCEPTED SCHEDULES

For an Engineering Department using a Marine Design Consultant to prepare both the design and the working drawings, the objectives of the in-house Engineering Department include:

BASIC DESIGN

- Provide overall design leadership and direction
- Provide production oriented design requirements
- Provide continuous monitoring of project for unique production methods and facility involved
- MEET ALL ACCEPTED WORK SCHEDULES

PRODUCT ENGINEERING

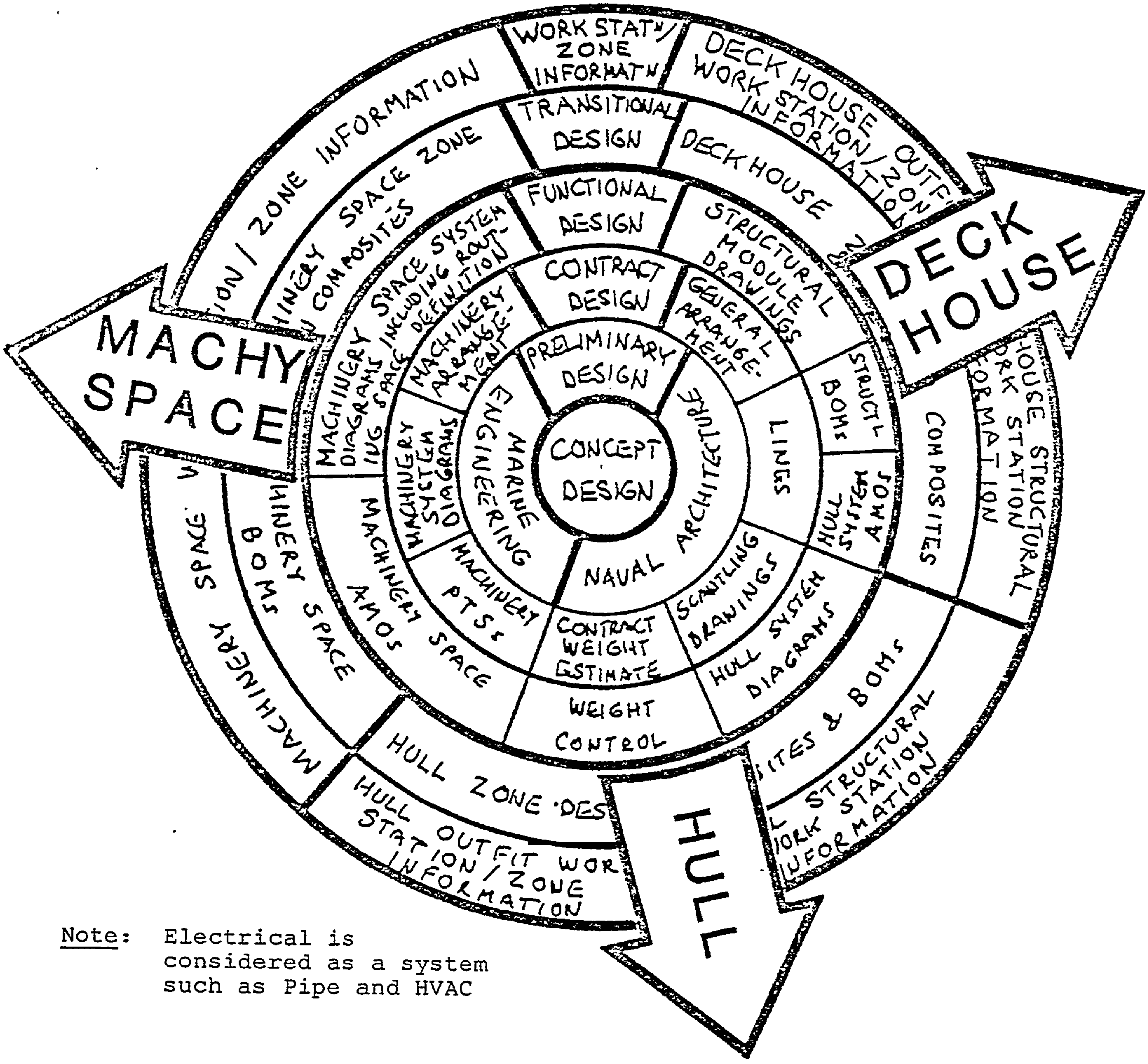
- Organize to best, support Integrated Shipbuilding
- Provide overall engineering leadership and direction
- Ensure engineering is developed in the way desired for shipyard rather than what the consultant wants to do'
- Prepare lofting, pipe assembly drawings, layouts, etc.
- Prepare the technical information to complete work packages required by Production Department
- Provide engineering liaison to Production Department
- MEET ALL ACCEPTED WORK SCHEDULES

In both cases, the objectives should be reviewed regularly to enable a self-improving capability to flourish.

It has already been stated that the engineering organization should be compatible with the production organization. Actually, this is only necessary for the Product Engineering section. The Basic Design section can be functionally organized if it best suits its purpose. The

expanding data base concept (14) logically loads to the organization of the Product Engineering Section as three groups, namely; Hull, Deckhouse and Machinery Space. This is shown conceptually in Figure 24. With such an organization structure, no group is dependent on another group to complete their work, provide data or have another group check their work for interferences.

As an aid for developing a suitable Product Engineering organization, it is worthwhile to construct an Engineering Functi-Zone matrix such as Figure 25. Such a matrix, the different product engineering needs for the three zones can be determined. It can be seen that the Hull and deckhouse zones require the same functions, although the application will be different. However, the functions and application for the machinery space are quite different, being for a power plant rather than a distribution or service system. For this reason, it is proposed that product engineering be organized as three groups, namely Hull, Deckhouse and Machinery Space. Each group would consist of designers and some drafters experienced in their zone area who would be supplemented by drafters from a common drafter pool as the work required. Such an organization is shown in Figure 26. It is believed that U. S. shipyards would find it easier to change to this type of engineering organization than to the MarAd/SNAME IHI type.



Note: Electrical is considered as a system such as Pipe and HVAC

FIGURE 24 - BASIS FOR ENGINEERING SECTIONS BASED ON EXPANDING COMMON DATA BASE

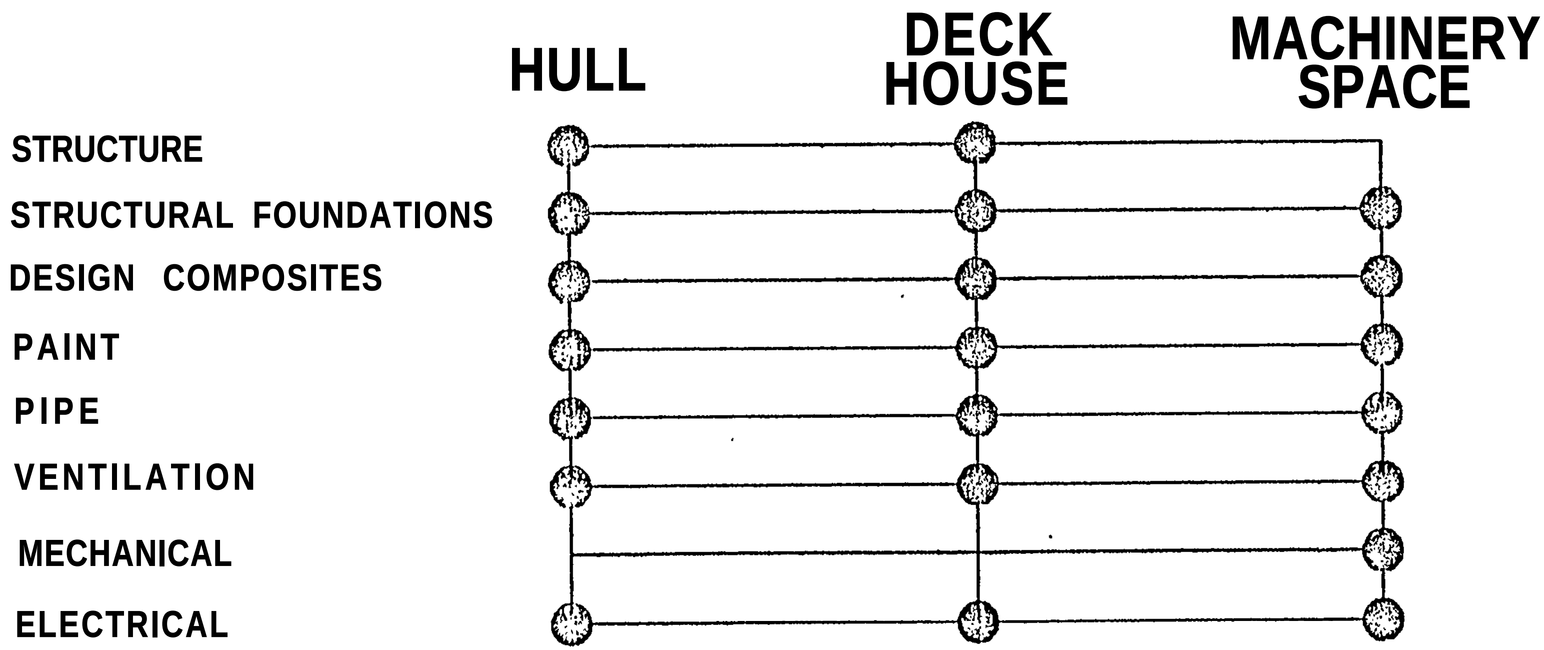


FIGURE 25 - PRODUCT ENGINEERING FUNCTION/ZONE MATRIX

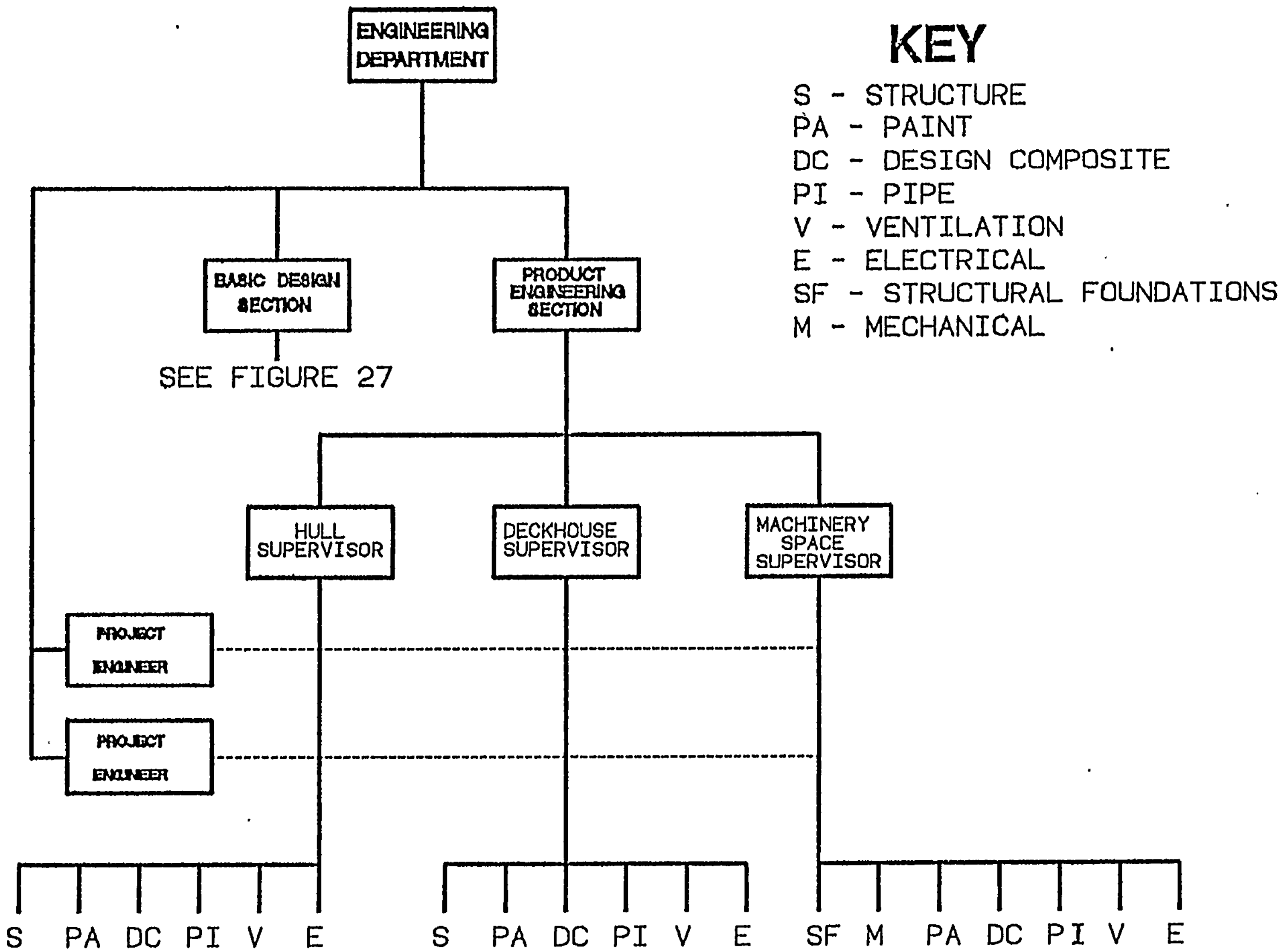


FIGURE 26 - ENGINEERING ORGANIZATION FOR ZONE CONSTRUCTION

All engineers, except those in management, liaison or those being trained, will be in the Basic Design section. The positioning of engineers in the production departments at all levels from department to work station has been shown by the Japanese to lead to significant benefits due to maintaining a high technology level in production and promoting superior communication. In U. S. shipyards the duties and responsibilities of such engineers could be equivalent to' those in Japanese shipyards, where they are involved in planning, scheduling, material flow, accuracy control and manning requirements for their area of responsibility, or they may be restricted to the usual U. S. role of engineering liaison. in any case, such an approach would appear to be worthwhile for U. S. shipyards, as it would transfer the higher technical base out into the production department, and enable the engineers to gain production experience and better understanding of the production department's needs and problems by engineering.

A suitable organization structure for the Basic Design section in the hypothetical integrated shipyard is shown in Figure 27. It is a combined functional/matrix structure. The functions are the usual Naval Architecture, Marine and Electrical Engineering, whereas the matrix roles are for the Production and Systems Engineering input to the three functional roles. The Production and Systems Engineers are

directly responsible to the Basic Design Manager to direct, educate, train and monitor the functional engineers in production oriented design and systems integration respectively.

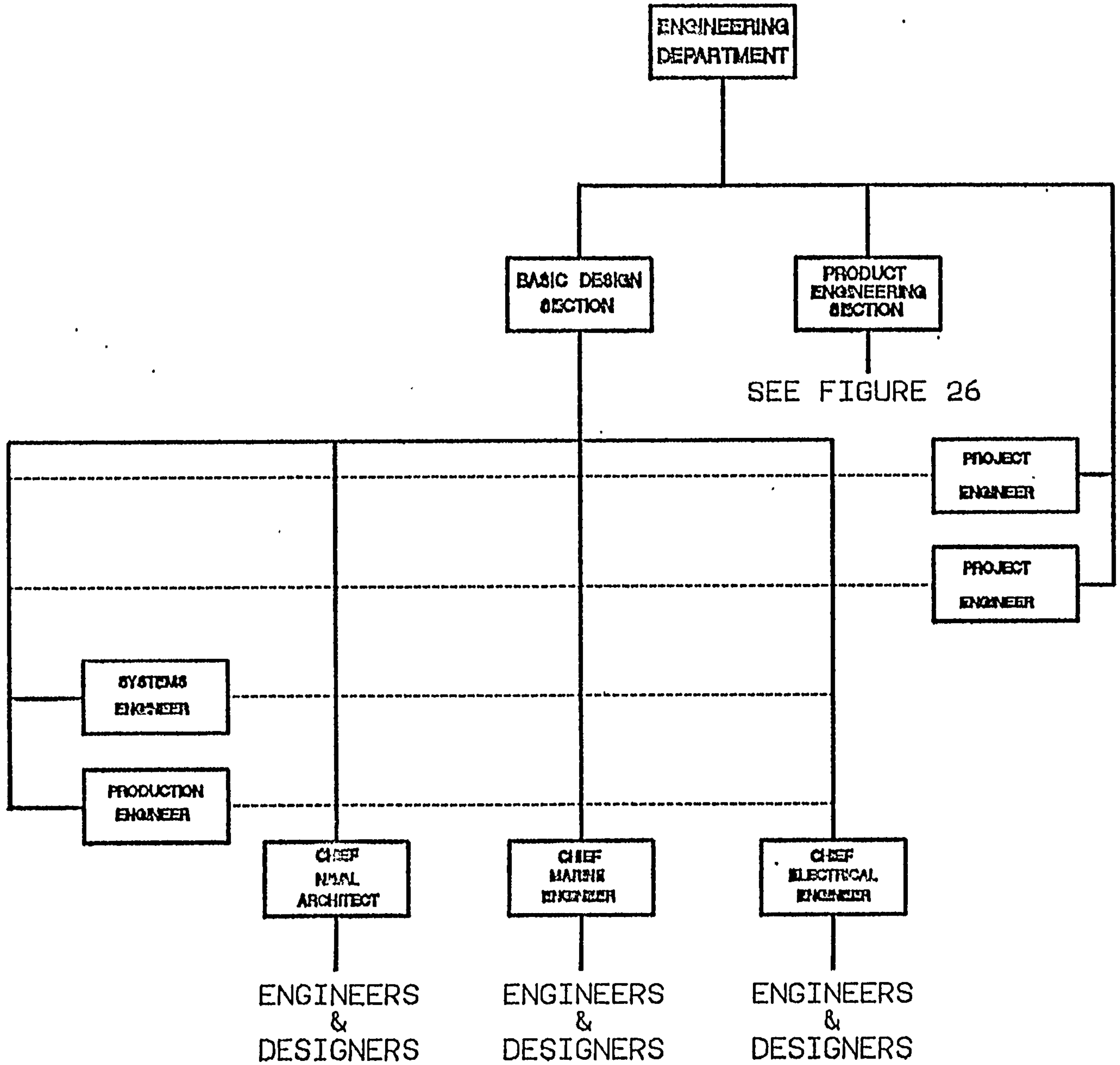


FIGURE 27 - BASIC DESIGN ORGANIZATION

5.0 ENGINEERING STAFFING FOR ZONE CONSTRUCTION

The staffing of the organization is one of the most important factors affecting its success. Even the best organization will not accomplish its goals effectively and efficiently if it is not staffed with the correct number of people with the correct balance of education, training and experience. This is equally true of all departments in a shipyard, not only engineering. In order for the modern shipbuilding methods to be accepted and competently used, it is necessary to upgrade the technical and educational level of all shipyard managers and supervisors.

It is often stated (15, 16) that the U. S. engineering problem is due to an inadequate number of engineers directly employed by the shipbuilding industry. While it is true that more engineers would give the engineering managers more. resources to accomplish the work, it may simply mean more engineers preparing the work in the same outdated inefficient way. It would obviously increase the cost of engineering so there would need to be a resulting greater reduction in production manhours for it to make sense.

Table 4 below gives the ratio of graduate engineers to total engineers in the U. S. aircraft and shipbuilding industry as wll as the same ratio for British and Japanese shipyards.

TABLE 4 - GRADUATE ENGINEERS/1000 EMPLOYEES

U. S. Aircraft Industry	10
U. S. Shipbuilding	5
British Shipbuilding	6
Japanese Shipbuilding	52

The SNAME SP-2 Panel on Education and Training issued a report on "Curricular Needs of Shipyard Professionals" in June, 1984. This report shows that for 10 U. S. shipyards, the ratio of Graduate Engineers per 1000 employees was actually 14. Before it is concluded that this means that everything is therefore fine in the industry, it should be noted that the same report states that only 20 percent of the engineers were naval architects and marine engineers. The report states, "this means that the other 80 percent of the entry level technologists most likely have not been exposed to the shipbuilding industry prior to graduation."

Table 5 (from reference 17) shows the ratio for both graduate engineers and designers for British shipbuilding. It can be seen that the number of graduate engineers has fallen from 13 to 6 per 1000 employees since 1965 to 1974. The total number of technical staff has, however, remained constant at about 60 per 1000 employees. The natural question is does the shipbuilding industry really only require half the number of engineers that are necessary for the aircraft industry? Japanese experience shows a significantly higher

TABLE 5 Technologist & Technician Statistics for Shipbuilding Industry

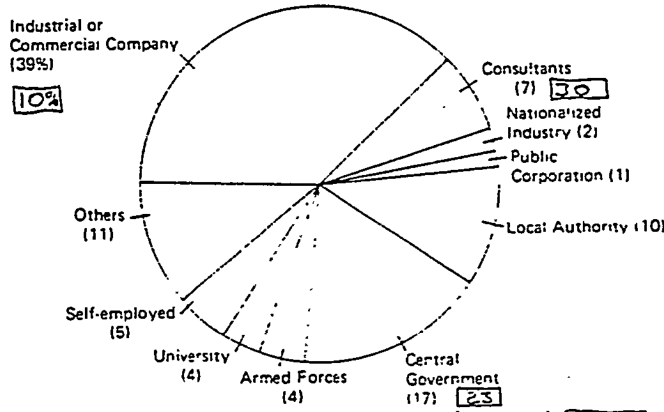
	Numbers Employed						
Occupation	1965	1967	1968	1969	1970	1971	1974
Qualified Scientists & Engineers	1794	1599	957	771	545	445	598
Design & Other Draughtsmen	3863	3755	4084	3767	3796	3284	3473
Other Technicians	2283	2092	2336	2663	2214	1887	2071
Total Technicians	6146	5847	6420	6430	6010	5171	5544
Total of All Employees	136,059	128,649	121,454	120,196	122,250	115,802	100,886
QSE/Total Employees	1·32%	1·24%	0·79%	0·64%	0·45%	0·38%	0·59%
Total Tech./Total Employees	4·52%	4·54%	5·29%	5·35%	4·92%	6·09%	5·50%
(QSE + Total Tech)/Total Employees	5·84%	5·78%	6·08%	5·99%	5·37%	6·37%	6·09%
Total Tech/QSE	3·43/1	3·66/1	6·71/1	8·34/1	11·03/1	11·62/1	9·27/1
Draughtsmen/Total Tech	62·85%	64·22%	63·61%	58·58%	63·16%	63·51%	62·64%

Notes: Qualified Scientists and Engineers (QSE) include all employees who hold a university degree or equivalent, or are corporate members of appropriate professional institutions.
Prior to 1968 the IINC was included in the definition of QSE but was subsequently excluded.
Prior to 1960 tracers were included with draughtsmen.

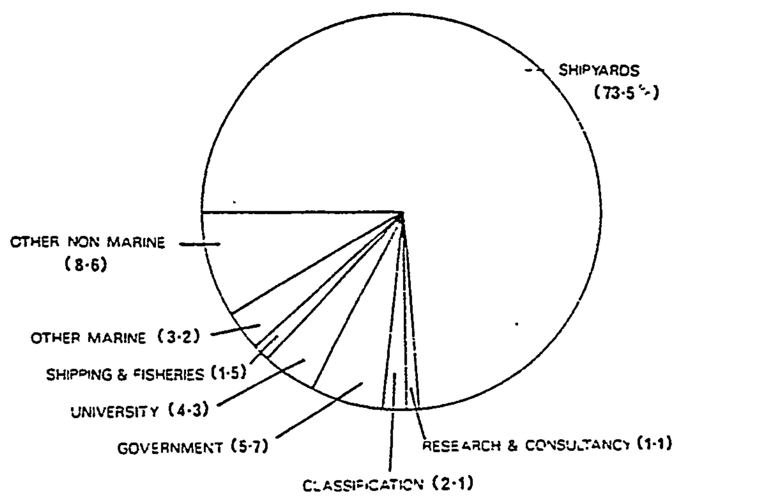
ratio. However, it is necessary to look at the Japanese ratio closer to make sense of the comparison. Japanese graduates are of two types; the first is similar to U. S. and European engineering graduates, and the second is similar to a technical college student. The second type is not included in the U. S. or British ratios in Table 4. Nevertheless, it is probable that the Japanese ratio for the similar engineering graduates would be about 20 per 1000 employees, still significantly higher than the U. S. and Britain. It is suggested that this higher number of technically educated people in the shipyards is a major reason for their success in shipbuilding and advanced shipbuilding technology.

Figure 28 shows the employers of and occupation of Naval Architects in the U. S., Britain and Japan based on Figures from reference (18). Its message is clear! The U. S. needs more Naval Architects (and other engineers) in the shipyards. How can this be justified, let alone accomplished in a contracting industry? It must be by training engineers in the advanced shipbuilding technology and allowing them to practice the new way in both engineering and the other shipyard departments which must improve their performance to accomplish the goal of higher productivity and shorter building cycles for future ships. It is understandable that in the work scarce and competitive situation that U. S. shipbuilding is

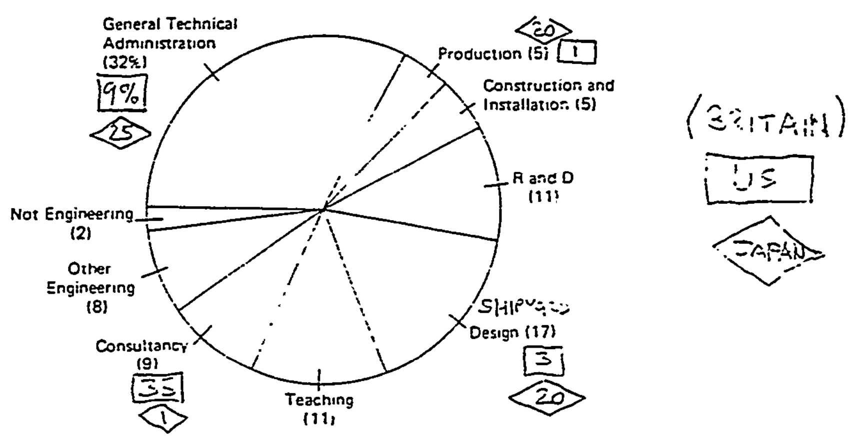
currently facing, it may be difficult for shipbuilding management to take such steps. However, it is probable that those who survive the current crisis will be the ones who try innovative solutions to the current problems.



Employers of Naval Architects (BRITAIN) US



Employers of Naval Architects in Japan



Occupation of Naval Architects by Type of Work

FIGURE 28 - NAVAL ARCHITECTS, EMPLOYERS & OCCUPATIONS

6.0 ENGINEERING TRAINING FOR ZONE CONSTRUCTION

Training is another major factor affecting the outcome of any organization. When it is realized that well planned and practical apprenticeships are almost non-existent in the U. S. shipbuilding industry, and that most engineers and designers are left to "learn the hard way", it is not surprising that it is close to the bottom of the shipbuilding technology ladder. It is essential for the U. S. shipbuilding industry to upgrade the knowledge level of shipyard employees. It will be futile to introduce advanced technology into shipyards if they are staffed by low level educated and trained personnel.

As it is obvious that there is not an abundance of engineering personnel already practicing the -proposed Engineering for Zone Construction, it will be necessary to educate and train existing and new shipyard design and engineering department employees as well as those of marine design consultants in the methods and procedures to be used.

Another problem that must be recognized is that todays shipbuilding management, including engineering, has been trained in the traditional ways and are often too busy dealing with everyday problems to take time to learn and completely understand new ways! In such an environment, new

graduates educated and others trained in advanced shipbuilding technology will be frustrated by the apparent. lack of interest shown by these busy managers.

Therefore, it is suggested that shipyards, either individually or in association with other shipyards and/or universities and technical colleges, offer the education and training that is required to provide the level of advanced shipbuilding technology to increase the possibility of successful operation in the near and far future.

The subject of training for any industry is complex and large. It is not even suggested that it can be covered in an engineering management paper. It was necessary to briefly discuss it in order to draw attention to the need for a well planned effort by each shipyard and even by the industry. Until such a system is in use, it behooves each engineer and designer to plan their own training.

With this in mind, a recommended reading reference on this matter is a recent paper by Dr. B. N. Baxter (19). Figure 29 which is from a paper by G. Sivewright in reference (21) indicates the thought and planning that must be expended to develop a successful program as well as guide the self trainer on areas to be developed to be a successful practitioner of Engineering for Zone Construction. The Common Core Basic Training programs that were established by the British

Shipbuilders Training Board for various professions in ship-building (20), are also useful guides. Another reference worthy of reading is the RINA Symposium on the Training for Naval Architecture and Ocean Engineering (21).

It should be remembered that education and training are the food and exercise essential for the healthy and sustained life of any business. The shipbuilding industry in the U. S. will not become competitive if left undernourished and unfit.

TECHNICIAN ENGINEERS AND TECHNICIANS - DIAGRAM OF TRAINING

NOTES:

Bridging Training Programmes contain elements of general and objective training to meet individual needs.

ARROW "A" – Trainee craftsmen selected as potential technicians to start general training

ARROW "B" – Trainee craftsmen during P.E. selected as potential technicians to start bridging training programme.

ARROW "C" – New entry adults and craftsmen selected as potential technicians or draughtsmen to start bridging training programme.

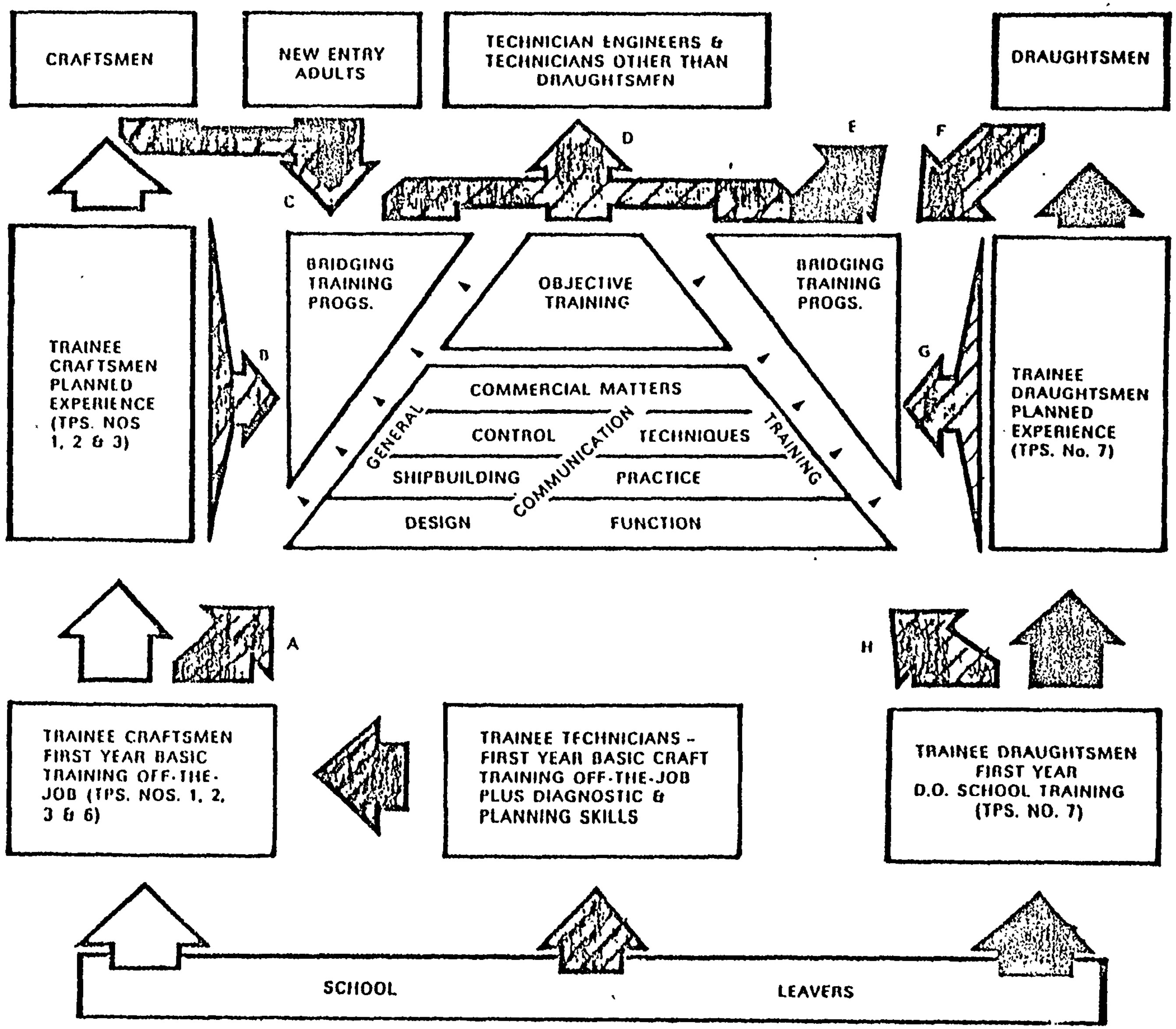
ARROW "D" – Trainee technicians complete technician training

ARROW "E" – Trainee draughtsmen recruited from craftsmen or new entry adults complete bridging training programme

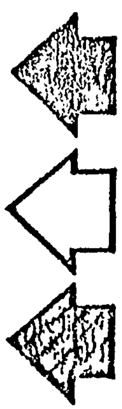
ARROW "F" – Trainee draughtsmen start other technician job training programme.

ARROW "G" – Trainee draughtsmen during P.E. selected for other technician jobs to start bridging training programme

ARROW "H" – Trainee draughtsmen on completion of first year training selected for other technician jobs start general training.



COLOUR KEY



Trainee Draughtsmen

Trainee Craftsmen

Trainee Technician Engineers and Technicians

FIGURE 29 - BRITISH SHIPBUILDING TRAINING PROGRAM

7.0 ENGINEERING PLANNING FOR ZONE CONSTUCTION

Engineering Planning for Zone Construction requires to be managed just like any other worthwhile activity. However, the Zone approach to engineering can reduce the complexity of management in the same way it simplified planning and scheduling. This is possible because of the following factors:

- o Elimination of duplication of effort and data.
- o Organized to suit zones.
- o Integration of lofting and planning with engineering.
- o Material designed, selected, procured and scheduled by zones.
- o All engineering disciplines working on each zone at the same time.
- o No issue of engineering information before it is completed for all disciplines for each zone.

As in any business, assuming an effective organization is in place, planning, scheduling and control are the keys to success. Without them, the basic concepts of the modern integrated 'shipyard would be unworkable. Therefore, it is likely that in a modern shipyard, an integrated management information system will be used for these functions. In such 2 case, it is necessary for engineering to prepare the information used by the system. Even with such an integrated system, it is probable that engineering prepares two schedules which are unique to its function and they are:

- Drawing Schedule

  This schedule should list all product engineering drawings which are required to construct the ship. It should have an upper and lower row for each entry in which scheduled and actual dates are listed respectively. Columns should be provided for dates for drawing start, completion, submitt21 to owner, classification and regulatory bodies, and issue. The drawing schedule is used for a number of purposes by the shipyard and others, such as an index of drawings and as a record of approval action. It should not be used to control or progress the project. The drawing schedule could be an automatic fallout from the integrated planning, scheduling and control system as all the information is in the common data base.

- Purchase Specification Schedule

  This schedule is required by the shipyard as a means of approval control of major purchased equipment and machinery by the owner. It can also be used by the shipyard to record the status of activity on major equipment and machinery procurement. Again, it could be an automatic fallout from the integrated management system as all the required information would be in the common data base.

There are still many shipyards where the different departments plan, schedule and control independently! A major or key event schedule is used as the integrating document but it is difficult to keep up to date for changes in any of the independent systems.

The outcome is usually unreliable, confusing and an open invitation to conflict between the various departments. If an integrated system is not used, the engineering department must utilize a planning, scheduling and control system of its own. In this case, it is important that the output from this department system can be utilized by purchasing and production as input to their systems. The system must provide as a minimum the three basic decisions and the four feedbacks mentioned in Section 1.0 Introduction. The system should be simple to use. For example, it should accept employee timecard data without an preprocessing manipulation and minimum additional data.

Such 2 system was developed some years ago by the author and will be briefly discussed. It uses the initial planning, scheduling and budgeting information as the basis and requires only progress estimates in addition to the employees normal timecards. Even this can be eliminated by using completion of previously performed tasks as the performance efficiency. Figure 30 shows the report form that connects engineering, purchasing and production schedules together. It does not include purchase technical specifications. It is prepared to tie together issue dates for drawings and other engineering information to production and Bills of Material to purchasing. The report form is not used by engineering to progress or control the project. Figure 31 is the schedule and work assignment bar chart. The chart is produced from the initial schedule and budget information and is continuously updated.

It shows when each task is scheduled to be worked on, how many hours to be worked each day and scheduled issue. As each report is issued, it also shows actual time worked on each task. This prevents the deliiy erately misleading practice of starting and recording the start for a task on the scheduled day and then delaying any further work until later. It is also possible to show the various stages of work on 2 task, such as design calculations, drawing preparation, BOM preparation, checking, rework after checking, and rework after approval. By comparing the scheduled time against actual time for the last two items, an actual indication of the technical excellence, or otherwise, of the engineering department will be given.

PROJECT NO 123 ENGINEERING EXTERNAL DOCUMENT SCHEDULE AND RECORDING REPORT REPORT DATE 6-4-76

IDENT NO	TITLE		SKETCH OR DRAWING START	SKETCH OR DRAWING COMPLETION	DRAWING APPROVL	DWG ISSUG TO YARD	BOM TO PURCH	SHOP SKETCH TO YARD	N/C TAPE ISSUE TO YARD	PROCESS SHEET TO YARD
390-2100	LOWER FWD DEEP TK P	SCHD	1/ 5/76	1/30/76				3/26/76	4/23/76	4/23/76
	UNIT 3-90 SHOP SKETCH	ACTUAL	1/ 5/76	1/27/76				3/19/76	4/23/76	4/23/76
391-2100	LOWER FWD DEEP TK S	SCHD	12/20/75	1/30/76				3/26/76	4/23/76	4/23/76
	UNIT 3-91 SHOP SKETCH	ACTUAL	12/20/75	1/29/76				3/26/76	4/28/76	4/28/76
392-2100	UPPER FWD DEEP TK P	SCHD	1/ 5/76	1/30/76				3/26/76	4/23/76	4/23/76
	UNIT 3-92 SHOP SKETCH	ACTUAL	1/ 5/76	1/27/76				3/26/76	4/23/76	4/23/76
393-2100	UPPER FWD DEEP TK S	SCHD	1/19/76	2/ 6/76				4/ 2/76	4/30/76	4/30/76
	UNIT 3-93 SHOP SKETCH	ACTUAL	1/19/76	2/ 4/76				4/ 2/76	4/24/76	4/24/76
394-2100	LOWER BOW	SCHD	2/ 2/76	2/13/76				4/ 9/76	5/ 7/76	5/ 7/76
	UNIT 3-94 SHOP SKETCH	ACTUAL	2/ 2/76	2/13/76				4/ 2/76	5/ 7/76	5/ 7/76
395-2100	UPPER BOW	SCHD	2/ 2/76	2/13/76				4/ 9/76	5/ 7/76	5/ 7/76
	UNIT 3-95 SHOP SKETCH	ACTUAL	2/ 2/76	2/13/76				4/ 9/76	5/ 7/76	5/ 7/76
396-2100	FOCSLE	SCHD	1/26/76	2/20/76				4/16/76	5/14/76	5/14/76
	UNIT 3-96 SHOP SKETCH	ACTUAL	1/26/76	2/18/76				4/12/76	5/ 7/76	5/ 7/76
397-2100	DECKHOUSE	SCHD	1/19/76	2/20/76				4/16/76	5/14/76	5/14/76
	UNIT 3-97 SHOP SKETCH	ACTUAL	1/21/76	2/24/76				4/16/76	5/14/76	5/14/76
1-2401	RUDDER	SCHD	2/ 2/76	2/27/76	4/ 2/76	4/23/76	4/23/76		5/21/76	5/21/76
		ACTUAL	2/ 4/76	2/27/76	3/25/76	4/23/76	4/20/76		5/25/76	5/21/76
1-2402	RUDDER STOCK	SCHD	1/26/76	2/13/76	4/ 2/76	4/23/76	2/16/76			
		ACTUAL	1/26/76	2/13/76	3/25/76	4/16/76	2/16/76			
1-2403	RUDDER ARRANGEMENT	SCHD	1/12/76	1/30/76	4/ 2/76	4/23/76	2/16/76		6/25/76	6/25/76
		ACTUAL	1/ 5/76	1/28/76	3/25/76	4/16/76	2/16/76			
1-2501	MAST ARRG & DETAILS	SCHD	3/15/76	4/16/76	6/18/76	7/12/76	6/18/76		8/ 9/76	8/ 9/76
		ACTUAL	3/15/76	4/16/76						
1-2503	YARDS & STAFFS ARRG &	SCHD	4/ 5/76	4/30/76	7/ 2/76	7/26/76	7/ 2/76			8/23/76
	DETAILS	ACTUAL	4/ 7/76	4/30/76						
1-2504	MISC DAVITS	SCHD	3/29/76	4/30/76	7/ 2/76	7/26/76	7/ 2/76			8/23/76
		ACTUAL	3/29/76	5/ 3/76						
1-3101	MOORING ARRANGEMENT	SCHD	3/22/76	4/23/76	6/25/76	7/19/76	6/25/76			8/16/76
		ACTUAL	3/18/76	4/21/76						

FIGURE 30

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PROJECT NO 123                        ENGINEERING WORK SCHEDULE AND RECORDING CHART                         REPORT DATE   5- 6 -73
                                                                                                            PAGE  5
ANNUAL CALENDER DAYS  63     70     77     84     91     98    105    112    119     126    133    140    147    154    161
              ISSUE          12MAR73       26MAR73        9APR73       23APR73        7MAY73        21MAY73        4JUN73
              DATE           SMTWTFS       SMTWTFS       SMTWTFS       SMTWTFS       SMTWTFS       SMTWTFS       SMTWTFS
DATA     CHG  EMPLOYEE             19MAR73        2APR73       16APR73       30APR73       14MAY73        28MAY73       11JUN73
NO       NO   NO                   SMTWTFS       SMTWTFS       SMTWTFS       SMTWTFS       SMTWTFS       SMTWTFS       SMTWTFS

1-3601   111   5-21-73        11111  11111  11111  11111                             D               I
                              22222  22222  22222  22222                             D
                                                                                     D
               201060         46645  66442  88648  64438  48                         D
               237723         86448  48846  48848  68470  8                          D
                                                                                     D
         112                              . 88888  88888  88888  88888               D
                                                                                     D
               201060                       2 24   2 445  4 42         24            D
               237723                       2  4   2  41   442         3 4           D
               291061                       44444  44444  44 44  64844 244           D
                                                                                     D
         113                                                            88888        D
               157119                                                     8888 8     D
                                                                                     D
1-3602   111   5-28-73               88388  88888  88838  8883                       D                      I
                                                                                     D
               237125                88484  8888 8 88888  4241                       D
                                                                                     D
         112                                       44444  44444  4444                D
                                                                                     D
               291061                              44444  44444  2424   4            D
                                                                                     D
         113                                                                    88888D
               157119                                                            8888D
                                                                                     D
1-3603   111   6-18-73                                           88888  88888 88888  D 888                                     I
                                                                                     D
               201060                                            88888  64888   888  D
                                                                                     D
         112                                                                  44444  D 44444  44
                                                                                     D
               291061                                                         4466   D
                                                                                     D
         113                                                                         D               888
                                                                                     D
                                                                                     D
```

FIGURE 31

The program works back from the required issue date for engineering information allowing for approval times and determines days on which work must be done. If a start date is inputed, the number of hours required to be expended each day is also calculated and given. Otherwise the days are scheduled on the basis of an 8 hour day. The program adds up the scheduled hours to be worked each day and gives a total. Peaks and hollows in the daily work demand can be easily seen and adjustments made to even out the manning requirements. The program does not currently include an automatic resource allocation capability. Thus, the Schedule and Work Assignment Report shows the three basic data requirements. By processing time charged to each task from the employees' normal timecards, each issue of the report is an excellent visual aid to quickly show how well the schedule is being adhered to. Thus, the first feedback question can be answered. By incorporating estimated completion of each identified task, the program will develop data to answer the remaining three feedback questions, thus enabling analysis and resulting decision and action. This information is shown in the performance report such as Figure 32. It reports on the performance of the work compared to the budget and determines individual variance as well as total product variance. It also projects time required for completion of each task and total project, and indicates whether individual tasks can be done in time, with and without overtime. Therefore, the report clearly shows any task that is in trouble. This is again summarized for the total project as shown in Figure 33. The system therefore is capable of indicating any problems, such as delay and low performance and what is necessary to get back on schedule and improve performance.

These reports have been found to be adequate tools to enable a number of engineering projects to be successfully managed and the necessary schedule data communicated to purchasing and production departments. However, it is restated that to achieve the desired high productivity, short building cycle shipbuilding, engineering planning, scheduling and control should be a part of an integrated management information system utilizing a common data base.

ENGINEERING PROJECT PERFORMANCE REPORT

GROUP REPORT

PROJECT NO 123 GROUP NO 410 REPORT DATE JUNE 7,1976 PAGE 7

DWG OR ITEM NO	DESCRIPTION	CHG NO	COMP DATE	EST HOURS	PCT COMP	ALLOWED HOURS	ACTUAL HOURS	VAR HOURS	VAR PCT	PROJD HOURS	SCHD DAYS	DAYS REMN	DAYS REQD	DAYS LATE	REQD O/T HRS/DAY
1-3302	CARGO TANK	111	22MAR76	160	100	160	146	14	8.8	146	20	0	0	0	0
	HATCH COVERS	112	29MAR76	24	100	24	28	- 4	-16.7	28	3	0	0	0	0
	ARRG & DETAILS	113	12APR76	24	100	24	19	5	20.8	19	3	0	0	0	0
		116	26JUN76	16	0	0	0	0	0	0	2	2	0	0	0
1-3401	AIRPORT &	111	26APR76	240	100	240	264	-24	-10	266.7	30	0	0	0	0
	WINDOW LIST	112	3MAY76	40	100	40	32	8	20	32	5	0	0	0	0
		113	17MAY76	40	100	40	44	- 4	-10	44.4	5	0	0	0	0
		116	12JUL76	24	0	0	0	0			3	3	3	0	0
1-3601	HULL INSULATION	111	12MAY76	120	100	120	110	10	8.3	110.0	15	0	0	0	0
	ARRG & DETAILS	112	19MAY76	16	100	16	20	- 4	-25	21.3	2	0	0	0	0
		113	31MAY76	16	0	0	0	0			2	2	0	0	0
		116	29JUL76	12	0	0	0	0			1.5	1.5	1.5	0	0
1-3602	JOINER WORK	111	24MAY76	320	100	320	290	30	9.4	353.2	40	0	0	0	0
	STANDARD DETAIL	112	7JUN76	64	60	38.4	42	- 3.6	- 9.4	66.4	8	0	3.5	3.5	XXX
		113	21JUN76	64	0	0	0	0			8	8	8	0	0
		116	16AUG76	40	0	0	0	0			5	5	5	0	0
2-3602	JOINER WORK	111	31MAY76	120	100	120	110	10			15	0	0	0	0
	ARRANGEMENT	112	7MUN76	16	80	12.8	8	4.8	37.5	10.0	2	0	1	1	XXX
	MAIN DECK	113	14JUN76	16	0	0	0	0			2	2	2	0	0
		116	2AUG76	12	0	0	0	0			1.5	1.5	1.5	0	0
3-3602	JOINER WORK	111	14JUN76	160	80	128	150	-22	-17.2	193.2	20	5	5.4	0.4	.64
	ARRANGEMENT	112	21JUN76	24	0	0	0	0			3	3	3	0	0
	01 DECK	113	28JUN76	24	0	0	0	0			3	3	3	0	0
		116	5JUL76	16	0	0	0	0			2	2	2	0	0
4-3602	JOINER WORK	111	5JUL76	400	60	240	255	-15	- 6.3	426.9	50	20	21.5	1.5	.6
	ARRANGEMENT	112	19JUL76	80	0	0	0	0			10	10	10	0	0
	02 DECK	113	2AUG76	80	0	0	0	0			10	10	10	0	0
		116	9AUG76	40	0	0	0	0			5	5	5	0	0
5-3602	JOINER WORK	111	12JUL76	320	30	96	88	8	8.3	293.4	40	25	25.7	0.7	.23
	ARRANGEMENT	112	26JUL76	64	0	0	0	0			8	8	8	0	0
	03 DECK	113	9AUG76	64	0	0	0	0			8	8	8	0	0
		116	16AUG76	40	0	0	0	0			5	5	5	0	0

FIGURE 32

ENGINEERING PROJECT PERFORMANCE REPORT

SUMMARY REPORT

PROJECT NO 123 REPORT DATE JUNE 7,1976 PAGE 1

CHG NO	DESCRIPTION	EST HOURS	SCH PCT COMP	ACT PCT COMP	ALLOWED HOURS	ACTUAL HOURS	VAR HOURS	VAR PCT	PROJD HOURS	SCHD DAYS	DAYS REMN	REQD MEN/DAY
111	DRAFTING	9016	52.3	50.3	4517	4727	- 210	- 4.7	9460	200	80	7.4
112	BILL OF MATERIAL	2350	46.1	45.3	1065	1040	25	2.4	2294	200	90	1.7
113	DWG CHECKING	1840	37.5	39.7	730	710	20	2.7	1790	200	105	1.3
116	APPROVAL CHANGES TO DWG	2240	21.3	22.3	500	470	30	6.0	2106	200	145	1.4
117	ENGINEERING SUPERVISION	3800	33.3	35	1330	1345	- 15	- 1.1	3042	400	190	1.6
119	ENG SERVICES TO YARD	1500	7.4	5	75	100	- 25	-33.3	2249	400	385	0.7
121	PURCHASE SPECIFICATION	400	100.0	100	400	393	7	1.8	393	20	0	0
122	MATERIAL ORDERING	600	100.0	81	486	470	16	3.3	580	25	0	XXX
123	VENDOR TECH ANALYSIS	400	95.3	97	388	395	- 7	- 1.8	407	150	75	0
125	VENDOR DWG APPROVAL	600	76.6	72	432	380	52	12.0	528	150	140	0.1
126	ALLOWANCE LIST	1000	0	0	0	0	0		1000	40	365	0.3
131	BOOKS AND MANUALS	450	25.3	30.	135	138	- 3	- 2.2	460	150	365	0.1
132	DWG REPRODUCTION	800	44.2	45	360	351	9	2.5	780	200	365	0.2
134	SCHEDULES AND PROG REP	240	36.6	35	84	80	4	4.8	228	300	385	0
135	CONFERENCES	400	36.6	35	140	146	- 6	- 4.3	417	300	385	0.1
136	TEST AND TRIAL AGENDS	200	0	0	0	0	0		200	20	20	1.3
141	TAPE CONTROL	1200	57.6	59	708	699	9	1.3	1184	75	50	1.2
142	MATERTIAL REQUISITION	200	50.1	52	104	100	4	3.9	192	20	60	0.2
143	PROCESS SHEETS	400	50.1	52	208	198	10	4.8	381	30	60	0.4
	CONTRACT TOTAL	27636	42.9	42.2	11662	11742		- 3.1	28491			18.0

FIGURE 33

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9.0 ACKNOWLEDGEMENTS

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Comment by L.D. Chirillo on
"Engineering Management for Zone Construction"
presented by T. Lamb to the
11-13 September 1985 NSRP Annual Symposium

Any historian who writes in the future about shipbuilding would have to recognize the decade of the 1980s as one in which U.S. shipbuilding methods were revolutionized. What has, is and will continue to take place is a shift from system-oriented to zone-oriented logic. Thus, any paper which draws attention to problems associated with the transition is performing a useful service.

As the author suggests, before consideration of engineering management for zone construction, there must first be knowledge of how information can best be organized to incorporate a production department's build strategy. Thus, it is better to regard basic design as consisting of concept, preliminary and contract design only, and, most important, in fact vital, to regard contract design as part of the shipbuilding process. There is now precedent in the U.S. shipbuilding industry.

Exxon/Avondale for recently completed product carriers and Exxon/NASSCO for current tanker construction, worked together to produce mutually satisfactory contract designs which address both the owner's requirements and the shipbuilders' build strategies. With more development of statistical accuracy control methods, future such negotiations of technical matters before contract award will include the accuracy (quality) level that a ship will be built to.*

Of equal importance is the need to distinguish zone outfitting from pre-outfitting. "Zone" is a convenient contraction. What is really meant is "zone per stage", in other words, an outfitting opportunity ideal for a work package. Such opportunities can be recognized in a preliminary design, e.g., outfitting the forward half of an engine-room flat at first when it is upside down and latter when it is righted comprise two work packages that are envisioned before contract design starts. The description of such opportunities by production engineers is a build strategy which at first guides the development of contract design.

* This should be of keen interest to the U.S. Navy. Apprehensive about as-built accuracy, the Navy recently aurhorized photogrammetric surveys of entire hulls. In the commercial world, letters of intent are usually the basis for negotiating technical matters before contract award. The same approach does not seem possible for naval ships until there is realization that about 73% of naval shipbuilding funds is applied in only three shipyards mostly on a negotiated basis, e.g., for Nimitz-class aircraft carriers, Trident submarines and some lead ships of other types.

As contract, functional and transition design developments each make more information available, production engineers are able to refine their build strategy in time to guide succeeding design phases. Literally, the design output is work instructions per work package. There is no post design effort required wherein planners obtain bits of information from many system drawings in order to compose a work package for outfitting a block, for example, as in preoutfitting. In the absence of such sophisticated guidance from a production department starting with production engineering input to contract design, a design department will continue to work in isolation regardless of its organization.

The author's Table I is excellent. It can be summarized by saying that the zone approach features detail design, material planning and material procurement each progressing in the same sequence that work packages are organized for production, i.e, all departments perform per truly integrated schedules in accordance with a common strategy. Regretfully, the author's paper contains **a** gross error. Figure 19 does not reflect the organization described in **a** series of "MarAd/SNAME sponsored IHI" publications. The author's Figure 22, which describes an integrated hull construction, outfitting and painting organization, should be substituted. However, regardless of the author's notations, the organization shown in Figure 22 is entirely product oriented except for electrical, which remains functionally organized due to tradition **as** reported in one of the MarAd/SNAME/IHI publications. Also, product and process are synonymous in the context of Group Technology (GT) and process flows exist for outfitting and painting in addition to those for hull construction.

At the peak of shipbuilding activity in Japan, about 1974, IHI's organization consisted of three departments, hull construction, outfitting and painting, each of which addressed an <u>inherently different type of work</u>. This logic was extended within each department; a clean separation was maintained between fabrication and assembly work. For example, hull construction shops separately addressed part fabrication, sub-block assembly, block assembly and hull erection. As a consequence of such management specialization by products classified per GT logic, production line benefits were achieved to. a degree not achieved elsewhere for building ships.

Regarding fabrication of fittings, only a shop for manufacturing pipe pieces existed as virtually all other fittings, including foundations, were obtained from subcontractors. The objective was to concentrate management attention only where sufficient work flows could be obtained in accordance with GT, i.e., the production of pipe pieces.

Three outfit assembly shops were product organized by specialties, i.e., accomodation, machinery and deck (deck is other than accomodation and machinery), and, the fourth, electrical, was retained as a functional organication. Usually, the order is given as deck, accomodation, machinery and electrical, as shown in Figure 22, and the acronym DAME is used.

There is something to be learned from the affect of the continuing shipbuilding recession. Figure 5-3 of the MarAd/SNAME/IHI publication "product Work Breakdown Structure (PWBS) - Revised December 1982", shows the IHI organization as of about 1974. Since then, painting was changed from a two-shop department **to a** single shop assigned to the Outfitting Department. The next change combined sub-block assembly and block assembly under a single shop manager. The latest change combines hull construction and outfitting under a single department manager. Thus, as the work force gets smaller, there is a **tendency** toward **a** traditional functional organization.

However, such changes impact at department and shop levels only. For budgeting and costing purposes, work flows by problem categories at supervisory levels within shops remain separated so as to exactly match the PWBS employed. In this respect, Figure 5-3 is still valid. Its strength is in the exact matching of how work is organized within shops to the PWBS. The author's mixing of inherently different types of work in his suggested organization could not have the same powerful advantage.

While product organizations are preferred for all large manufacturing firms having high rates of technological change and need to be flexible in marketplaces, they cannot be applied dogmatically in search of "pure" organization form as the author proposes. After all, even with electrical as an exception, IHI's degree of electrical components, particularly electric cable, fitted on block is equivalent to or exceeds that achieved elsewhere. That which is produced, is definitely in conformance with product orientation. An overriding need is not for a pure organization of one form, instead, it is for the detail design, material marshalling and production efforts to be organized in the same way so as to enhance communications between them. Another overriding need is to get production people to develop a build strategy before contract design starts.

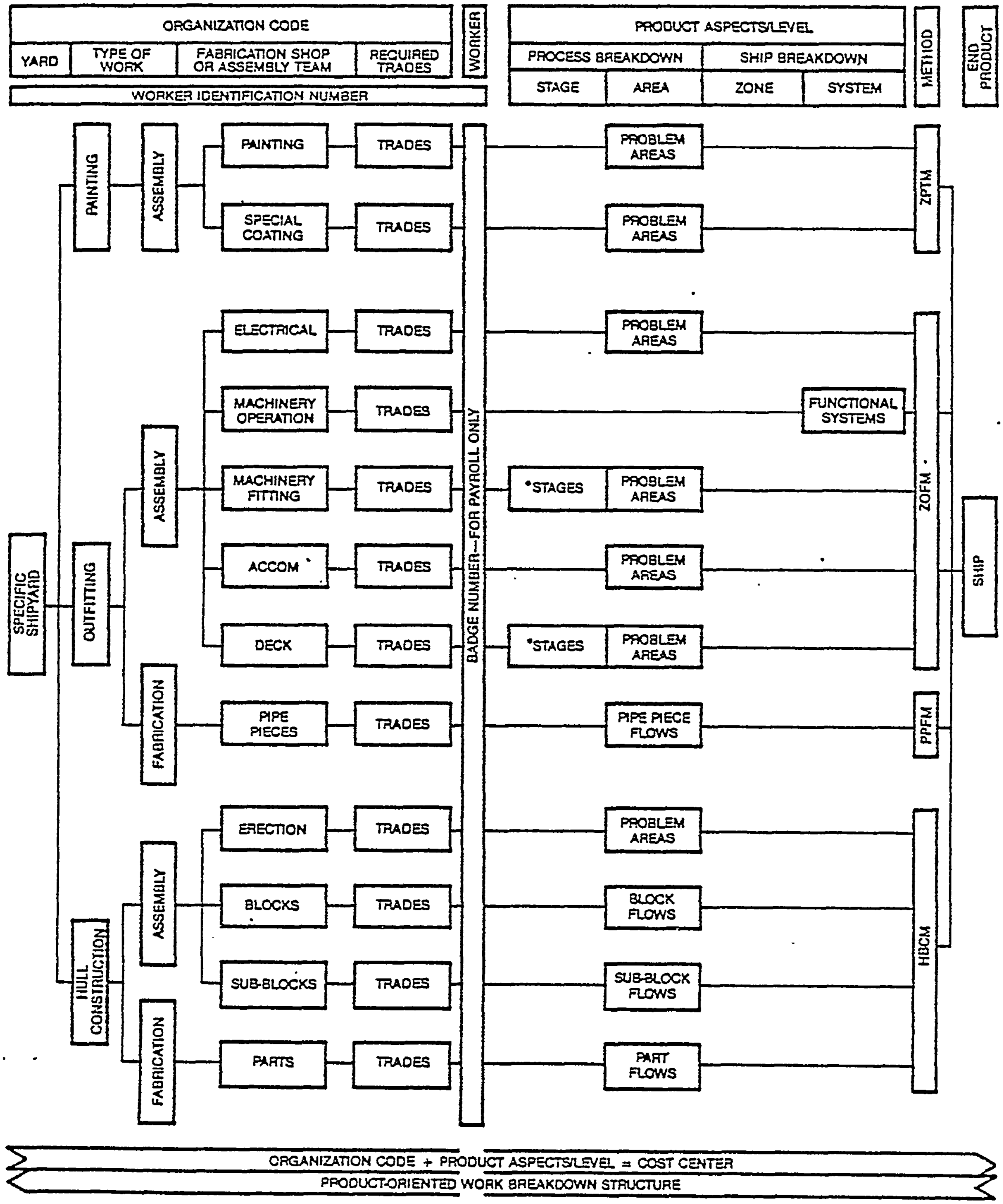

FIGURE 5-3: Typical Cost Centers are separately depicted by the horizontal combinations on each line. Cost centers shown *exactly match* the shipyard organization. With few exceptions, the yardsticks used for performance measurement are based upon work packages grouped by problem area per level. Yardsticks are whatever best suits circumstances at each manufacturing level. *Control by stage is added only when there are special or extensive welding requirements. Otherwise, welding incident to normal fitting is performed by fitters; control by problem area is sufficient.

DISCUSSION on T. Lamb's Paper "Engineering Management for Zone Construction of Ships"

I wish to compliment Mr. T. Lamb on his paper, which provides a valuable overview of various Engineering Management principles and its applicability to zone construction.

A question arises in regard to the reduced Engineering lead the required if zone construction is applied. I have read articles to the contrary. In general, the preparation of zone type drawings will still require complete development of many scantlings, piping, electrical systems and arrangements to make the zone construction drawing as intended, and. unless the Shipyard or Design Agent has a considerable Engineering staff (rather unlikely in today's 'market), this will require time.

The idea is to spend a bit core time "up front" and reduce the production. ***tine.***

Another area requiring some clarification is the ***term "zone"*** as used in the paper versus the use of this word by SNAME/IHI/IMOP.

we do agree with the concept of "Product Engineering" and the idea of incorporating the Planning function in this group, but the breakdown in Hull, Deckhouse and Machinery Space appears to apply only to commercial vessels, and, as Figure 26 illustrates, requires duplication of effort by the three (3) groups. For example, structural work is being done by two groups but in the Production area, will require the same skills, tools, facilities and materials. Thus, a single source for data provisioning would be more beneficial.

The Engineering staffing in shipbuilding is indeed a problem. However, considering the present shipbuilding market, this problem may be solved in the near future.

We anticipate that real shipbuilders will stay with us, but also be willing to accept the new concepts within the Industry, such ***as*** T. Lamb's paper outlines.

Discussion comments re: 20 August 1985

ENGINEERING MANAGEMENT

FOR

ZONE CONSTRUCTION OF SHIPS .

What Mr. Lamb is proposing in this paper has merit in that the elephant is eaten in smaller bites and more bites at the same time. This approach, if properly supported, will work. I think it would be wise to look at a 'few of these support requirements because without them, this approach to engineering/ design management will surely fail.

1. Early and Complete Staffing.

The traditional design spiral still remains as an integral requirement of the three basic breakdowns that are proposed in this paper ... HULL - MACHINERY SPACE - DECK ROUSE. The same functional requirements and trade-offs must be iterated. The difference in Mr. Lamb's approach is that it will require staffing of the three basic zones concurrently and early in all the functional areas. This will raise the number of functional engineers required over the traditional approach where the design spiral is iterated over the entire ship.

2. Interface Management.

The proof of the pudding in this design management approach is the interface of the three zones. None of the three areas can live as an entity to themselves. The problems associated with interface between the zones are myriad and are not addressed in this paper. Proper attention to this particular area is vital if the marriage of the zones is to be successful. There are many systems which of necessity must be-designed as a complete

system which cross the zone boundaries (HVAC, firemain, control and alarm, etc.). This effort must be identified and supported as input to the zones for the zone effort to succeed.

3. Management of Design "Schedule Busters":

The success or failure of this approach, as Mr. Lamb points out, is maintaining the design schedule. This will require Herculean effort on the part of design and purchasing personnel to obtain the required vendo'r information and also requires starting with complete technical specifications with the absolute, minimum of customer interference resulting from change orders. Figure 7 shows this dramatically where the engineering and material definition are shown concurrent for the first four months after contract award. The slope of these two curves is almost vertical in the fifth month. I submit that performance of this sort is impossible given the current competitive economic conditions in this country. It will be neigh on to impossible to select vendors, place purchase orders, and obtain the requisite design/vendor information in this time frame. I submit that this is the single greatest shortfall in this approach to engineering management for zone construction of ships.

Figure 7 also dramatically shows why the customer must maintain a "hands off" position in regards to changing the product after contract award. There is no time allowed in the design process to reverse or hold up any work once started. This is particularly germane in military construction where government change orders are a way of life.

4. Naval Contracts vs. Zone Construction:

It is no secret that for the foreseeable future in the United States that the U.S. Navy is about the only customer around. Unfortunately, this will place a huge roadblock in any serious effort to reduce the design and construction time of ships. The Naval Sea System Command and its associated contract requirements prohibit this improved performance. Vendor procurement requirements alone will throw the schedule way off. Poor contract specifications and a penchant for always updating specification requirements will ***throw*** enough "schedule busters" to choke the elephant we are trying to eat faster. The NAVSEA tech codes are still mired down in their systems approach to new construction. Where technical approval is required, you can forget about shortening any time cycle. NAVSEA and their attendant bureaucracy can-not react to zone construction design approach.

Another point to consider is that U.S. Naval Construction, particularly warships and amphibians, will require' more zones than the traditional hull-machinery space-deck house approach. Therefore, the staffing is that much more difficult and the interfaces grow accordingly.

I appreciate Mr. Lamb's approach and feel that it is aiming in the right direction. I question if it is doable-do with our current shipbuilding contract practices . . . particularly, naval contracts.

Respectfully submitted:

Frank H. McGrath
. Chief Engineer
. PETERSON BUILDERS, INC.

AUTHORS REPLY

I agree with Mr. Chirillo that it is vital for Contract Design to be part of the shipbuilding process and always suggest that it be developed along with the shipyard Building Plan (Build Strategy) for the design. There is no doubt in my mind that the cases he listed provided both the shipowner and the shipbuilder the best possible design to be constructed in the shipyard and operated by th owner. However, I dissagree that Functional Design should be excluded from Basic Design. I recognize that my approach is hot what IHI suggests, but as I see it Functional Design uses all the knowledge, skills and calculations that are used in eaflieridesign. It expands the incomplete Contract Design into a Total Design for the ship. Once Functional Design is completed, there should be no need for real "design" actions. Transitional Design, which could be called Transitional Detailing, involves the integration of the completed systems design into interference free, producible arrangements. Work Station/Zone Information preparation involves transmitting the data necessary for the production workers to fabricate and install the. components. Therefore, for my convenience as an engineering manager, I feel it is more logical and thus prefer to keep all design together under Basic Design.

I admit that Figure 19 does not look like the usual repres-encation of the IHI engineering organization but question whether it it is a gross error". my intent was to show the differences between Japanese, American and British approaches in three figures on the same page and thus tried to use a common nomeclature. I have prepared a revised but still modified organization for the IHI engineering to show my intention better in Figure 36.

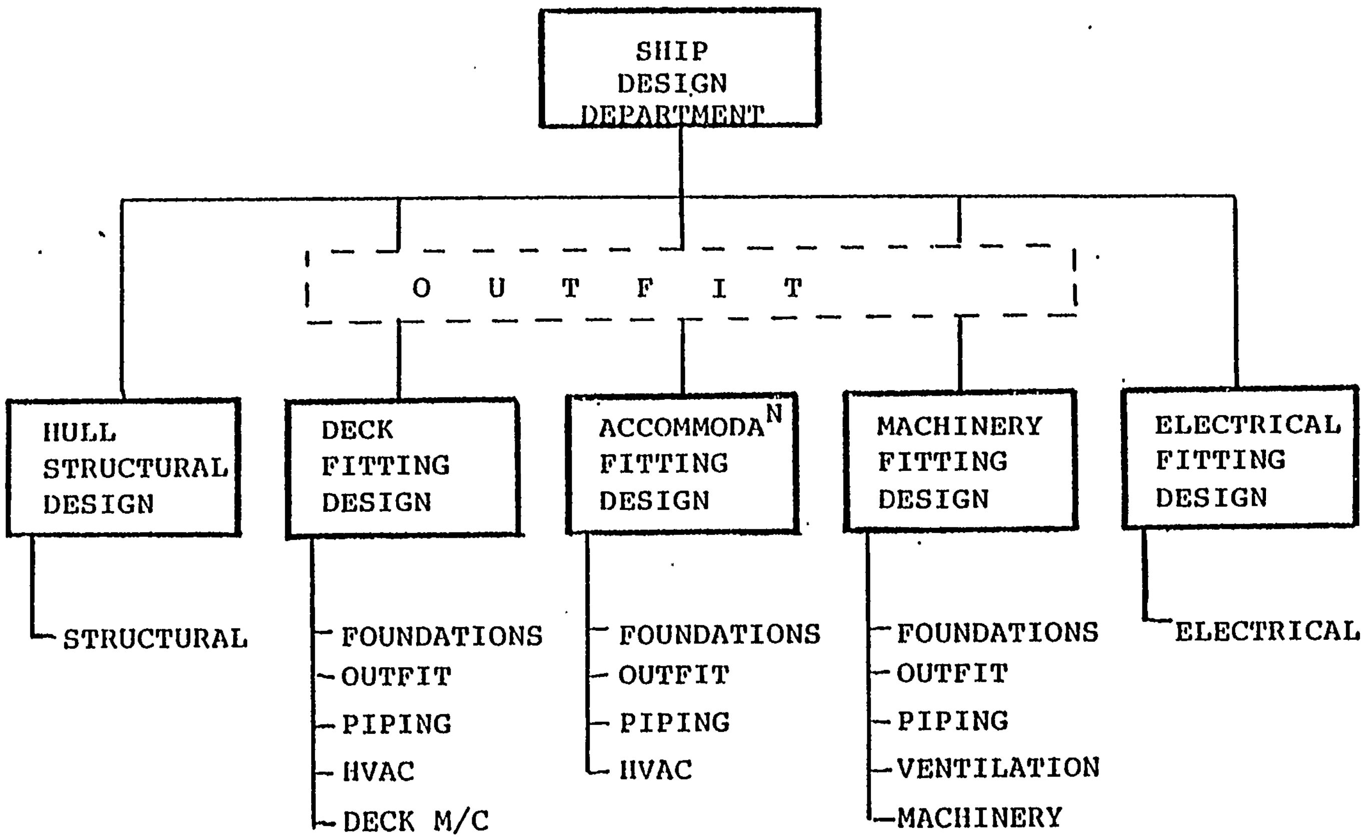

FIGURE 34 MARAD/SNAME/IHI ENGINEERING ORGANIZATION

I also dissagree that Product and Process are synonymous in the context of Group Technology. Mitranov, the father of Group Technology, clearly showed that Process Methods were in existance before and are a separate approach to Group Technology. However, the GT Method may utilize Process Methods within its production cells.

Mr Chirillo's update on the changes at IHI- confirms that most ideas can be improved uponly especially when circumstances' change. I used the word "pure" to describe what the IHI organization is not and as a consequence that as it is based on THEIR unique circumstances should not be copied but be adapted to suit another's, We should adopt their good ideas but leave those based on their traditional problems alone. We have plenty of our own traditions co deal with!

It is ***not*** and never has been my intent to detract from the valuable and important part played by the IHI Technology Transfer, but rather I am suggesting that the Japanese ideas can be adapted with/additional benefit for different shipyards and their circumstances in the same way the Japanese improved upon American and European shipbuilding ideas in the early 1960's.

I have been a life long believer and practitioner of the quotation by H. G. 'Wells, "chat one man's idea can always be improved in the minds of others". always

In reply to Mr. Posthumus, I am not suggesting that Engineering for Zone Construction allows reduced lead time but rather that Zone Construction along with shorter build cycles requires it.

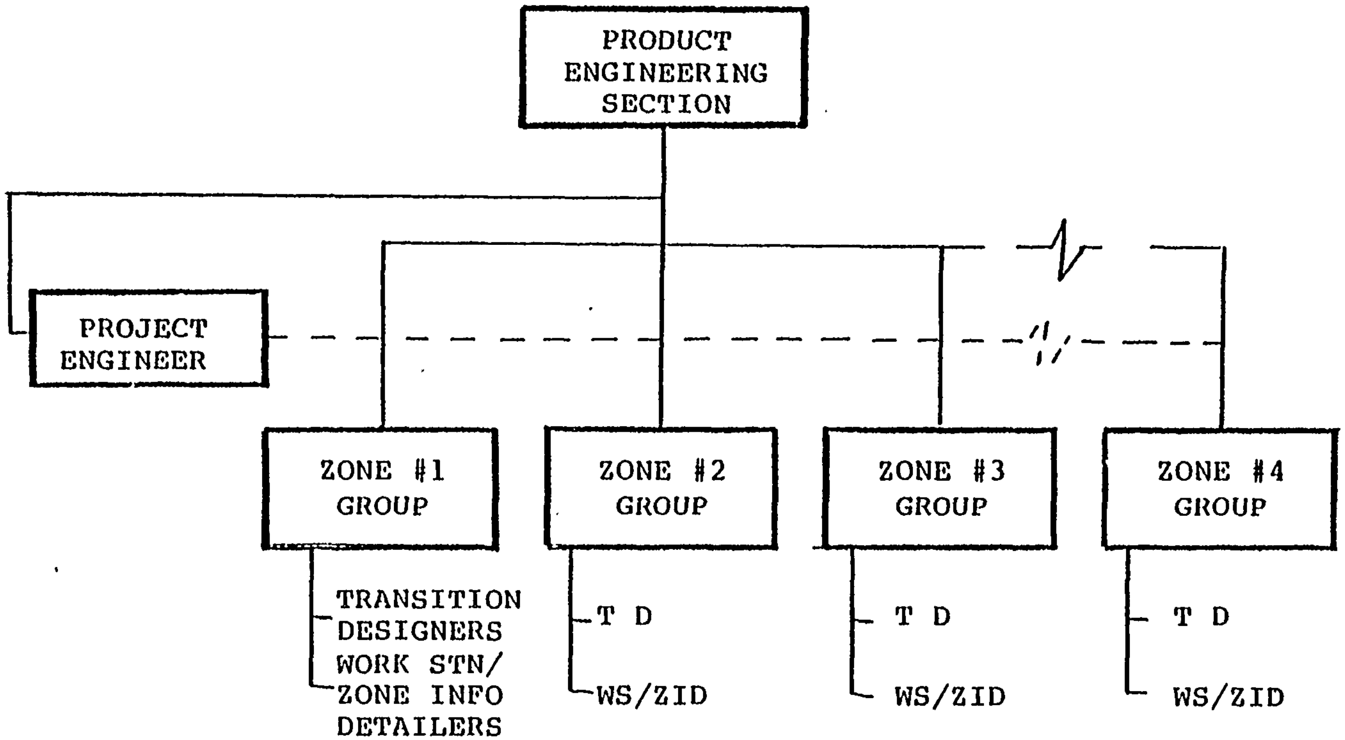

FIGURE 36 - PROPOSED PRODUCT ENGINEERING ORGANIZATION FOR WARSHIPS

of the zone groups are of only two designations, namely. Transition Designers and Work Station/Zone Detailers. This is another change (to the better, I believe) that I have mad2 based on my experience at TBC. As all design calculations and system diagrammatics are prepared during Basic Design (Functional), there is no need for knowledge of the different traditional disciplines in either Transitional or Work Station/Zone Information preparation but rather an overall integration and work practice knowledge instead.

It was amusing to me to see that Mr. McGrath has also been asked, "How do you eat an Elephant?" and knows that the answer is "in many small pieces". I never associated my approach with that technique and I thank him for doing so.

With regard to his specific comments, first, I dont see the traditional design spiral applying after the completion of Functional Design. Thus it would not impact the zone grouping in Product Engineering. The completion of design and the greater detail in preparing system routing diagrammatics during Functional Design MAY require more "Functional Engineers" but there will not be any increase due to any extension of the design spiral into Product Engineering.

Secondly, the logical completion and organization of the design during Functional Design provides the basis for an effective interface information and control. I agree that attention to this aspect is of extreme importance to the success of the approach.

Fortunately, by departing from the traditional structure first then machinery then electrical cascading preparation of engineering to complete engineering by zone, the task is reduced in scope. Instead of the traditional structure, piping, electrical and HVAC system arrangement drawings, structural module drawings and accurate dimensioned routing diagrammatics are prepared before commencing Product Engineering. This is fully discussed in the SNAME SP-9 Panel publication "ENGINEERING FOR SHIP PRODUCTION", to be published this Fall.

Mr. Posthumus is correct, I do use a different zone approach to the Zone/Area/Stage approach of the Japanese. My approach is based on my experience from shipyards that were using 'the zone approach in 1962. I have continued to expand the concept and its use to a hiearchical method similar to the one described in the paper. I use zones to define any desired portion of the ship in which work is to be performed in erected structural modules. Prior to that work is designated by work station and the engineering information is prepared for each work station.

The division of major zones into Hull, Deckhouse and Machinery Spaces is applicable to certain non-commercial ships, such as large warships where the deckhouse is a logical independent part. Also, I believe that the type of structural work being performed for Hull versus Deckhouse is sufficiently different to warrant its separation. However, I agree that for small combatants such as frigates or corvettes it is not the best approach, as I have found out since joining Tacoma Boatbuilding Company. For a number of reasons, the division shown in Figure 35 is better. The engineering organization shown in Figure 36 would then result. It should be noted that the staff in each

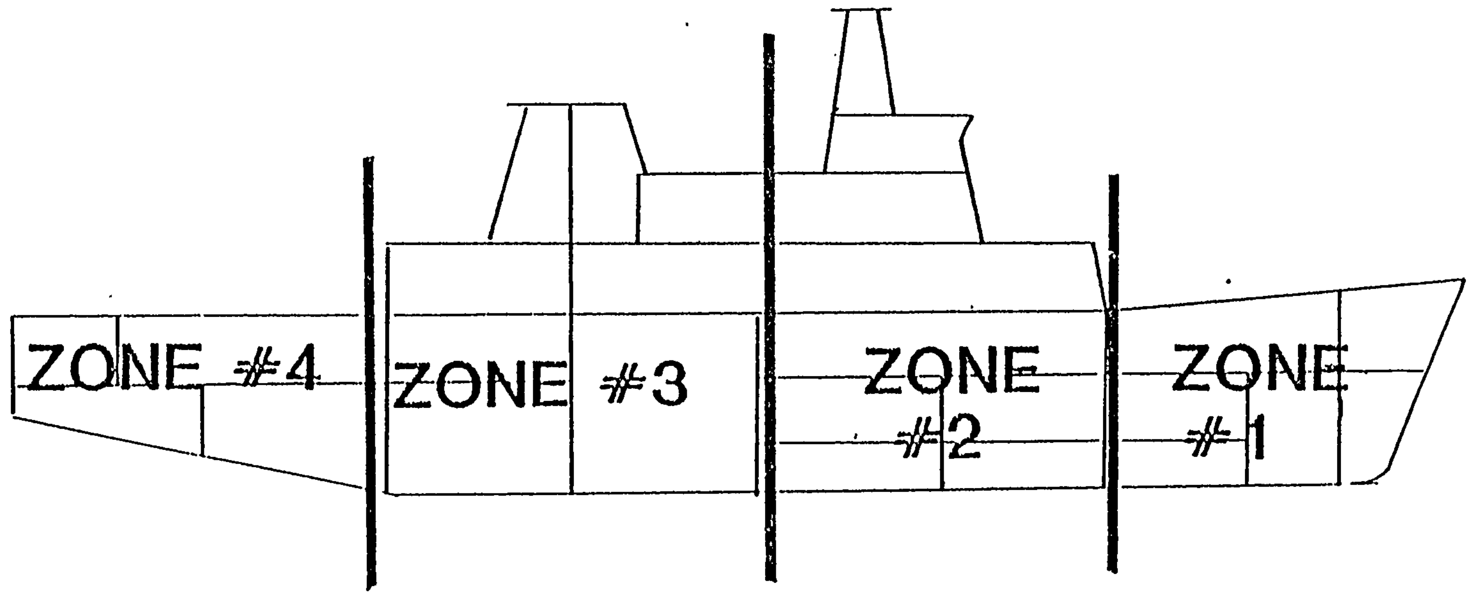

FIGURE 35 - ZONE DEFINITION FOR WARSHIPS

COMMENT by R.H. Slaughter, Jr. Ingalis Shipbuilding Division, Litton -

1. Education Aspects - Professionals

while much has been written about the benefits of zone construction methodology for shipbuilding as regards the construction process per se, only a few writers have addressed the necessity for radical changes in training of engineers to support the operations force. This paper begins to address this *issue.*

Paragraph b addresses the matter of training and provides some good references.

Paraphrasing the Biblical passage, "and a little child shall lead them", our "little children" are the undergraduate students in naval architecture marine, and ocean engineerng *courses in* various academic institutions. These students will learn something of the process of shipbuilding one way or another, and will only apportion a certain (small) amount of time to it. The following suggests a means of accomplishment that will attract student attention while not being burdensome to imliment

I submit that we take the simplest steps first and proceed about as follows:

a. Adopt as text material the National Shipbuilding Research Program (NSRP) monographs on the ,"new" method of shipbuilding. This work, done under the auspices of the ship production Committee (SPC) of the Society of Naval Architects and Marine Engineer (SNAME) is definite and concise. It has been we11 Americanized and males good source material

Academit instutitions will accept volunteer lecturers who have become "born again" shipbuilders to present lectures to students, on the basis that the way to build ships is the "new way Do not waste time discussing older convertional methods.

C. Utilize the SP-9 Panel (Training and Education) lesson plays and audio visual aids under development for these lecturers' use. This will standardize the presented material.

d. Cause the NSRP lectures to be "for credit", examining students on the material.

e. Establish programs, using the Sp-9 panel material, both to local Junior Colleges serving the industry, and to training organizations of shipyards and allied activities.

In following the above, we can rest assured that in a very few years, the new generation of entry-level engineers and technicians will infiltrate the industry and will *cause* the oldsters to see the light.

It will be amazing to see how quickly the older hands will pick up *new* ideas, even if from youngsters!

2. Measurement of cost Effectiveness, or If You Can't Measure It, *You* Can't Manage It

During the past secale and a half, the benefits to be derived by adopting the new technology have been propounded almost exponentially. Each shipyard that has changed methods

of Construction from conventicral to zone philOSophy has anncunced how great it is. Shipyard visits reveal units being erected and pre-outfitted to a markedly advanced degree. There is little fear That the pieces will not fit.

Lacking is measurement of the claimed cost effectiveness that will enable managers to evaluate in terms of dollars or percentages of manhour expencitures the expected return on investment. Such a discussion is coubtlessly beyond the scope of this paper, but the cost of engineering is a significant one in the cost of a ship, and the organization of the engineering departments has a. great bearino on that cost.

An analysis of Costs for various organizational structures described in the paper would be most interesting. It is suggested that discussion of engineering projectization by zone, exactly counterparting the planning and opercticns functions on a percentage of cost basis, would be most valuable.

The another has chronicled a very current and dynamic subject. He has brought into the open the involvement of engineerin in the methodology of zone construction. It is hoped that this work will be the impetus for him to pursue other aspects of shipbuilding bearing on zone technology, including financial aspects of adopting the new technology

The opinions expressed herein are those of the author and do not necessarily reflect policy or opinions of the Ingalls Shipbuilding Division of Litton.

Thirdly, the goal considered in the paper is to organize engineering to help U.S. shipbuilders become more competitive with shorter build schedules. I suggest that the current shipbuilding conditions in this country and the NAVSEA contracting practices make the proposed schedule performance unnecessary rather than impossible. However, all that this does is spread the schedule over a longer duration. The sequencing and the relative phasing remain the same.

Fourthly, I agree that Naval Contracts can deter innovative approaches to both design and construction. However, it should be appreciated that as the Functional Design PTS's, drawings, parts lists and schedules are complete, they are suitable for all approval actions.. No Product Engineering document is submitted for approval.

Finally, I dissagree that the approach is un-doable in today's conditions. Such an approach as described is not only doable it is necessary for U.S. shipyards that want to survive and are searching for significant productivity improvement from design through construction to successful delivery.

I appreciate Mr. Slaughter's suggestions on how to introduce new students to the "new" shipbuilding techniques and hope that they will be adopted. Both the University of Michigan and the University of Washington offer Ship Production Technology courses to their students. However, I see the bigger training problem for existing shipbuilders and that is why I persevered in my persuasion to have further education courses on Ship Production Technology at the University of Washington. The course has been held four times over the past three years.

The question of the "cost" of engineering for zone construction has been addressed in a general way by a number of sources, the best known being the Avondale IHI Technology Transfer report. The additional cost in manhours has been quoted from double to three times traditional engineering. This is not my findings. I have accomplished my proposed approach for a 30% increase for commercial ships and this increase was totally offset by elimination of planning effort. For a small naval combatant vessel, the increase was nearer 65% due to the special drawings (CDRL items) that the Navy still demands.

Documentation Center
The University of Michigan
Transportation Research Institute
Marine Systems Division
2901 Baxter Road
Ann Arbor, MI 48109-2150

Phone: 734-763-2465
Fax: 734-936-1081
E-mail: Doc.Center@umich.edu